MULTI-MARKET ANALYSIS OF THE IMPACT OF TRADE RESTRICTIONS ON IMPORTING LIVE ANIMALS INTO SOUTH AFRICA

by

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I hereby certify that, unless specifically indicated to the contrary in the text, this dissertation is the result of my own original work.

A BROUWER

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LIST OF ABBREVIATIONS

2SLS	Two-stage Least Squares
ADF	Augmented Dickey Fuller
AIDS	Almost Ideal Demand System
BG	Breusch-Godfrey
CD	Coubb-Douglas
CGE	Computarised General Equilibrium
CLRM	Classical Linear Regression Model
CPI	Consumer Price Index
DA	Department of Agriculture
DAPH	Directorate of Animal Production and Health
DAS	Directorate Agricultural Statistics
EU	European Union
FAO	Food and Agricultural Organisation
FOC	First Order Condition
FTA	Free Trade Agreement
GATT	General Agreement on Tariffs and Trade
GDP	Gross Domestic Product
GLES	Generalised LES
IAIDS	Inverse AIDS
ILS	Indirect Least Squires
I-O	Input-Output
LA/AIDS	Linear Approximate AIDS
LES	Linear Expenditure System
LES-AIDS	Linear Expenditure System AIDS
MIT	Meat Industry Trust
ML	Maximum Likelihood
NAMC	National Agricultural Marketing Council
OECD	Organisation for Economic Co-operation and Development
OLS	Ordinary Least Squires
PP	Phillips Peron
PPI	Producer Price Index
PRF	Population Regression Function
PSE	Producer Support Estimate

RMRDT	Red Meat Research and Development Trust
RPRI	Relative-Price Real-Income
SA	South Africa
SACU	South African Customs Union
SADC	Southern African Development Community
SAM	Social Accounting Matrix
SAMIC	South African Meat Industry Company
SRF	Sample Regression Function
SURE	Seemingly Unrelated Regression
USA	United States of America
WTO	World Trade Organisation

ABSTRACT

In SA different tariffs exist on the importation of meat. While a zero tariff applies on the importation of live animals imported for breeding or slaughtering, a ban exists on the importation of live animals for slaughtering purposes. This is based on the DA's opinion that slaughtering animals close to their place of origin and transporting the meat using modern refrigeration technology are better practices. Although the DA received only one official permit application, various firms expressed interest to import live sheep from Australia for slaughtering purposes. The motivation for and the purpose of the present study are to address the economic implications that such imports will have on the meat industry.

This study's main contribution was to estimate slaughtering functions for SA meat adopting a pragmatic approach using data for the period 1971 to 2002 on slaughterings, own and substitute meat prices, production costs, prices of complementary products, prices of other production alternatives, exposure to world markets, quality of grazing and heard numbers. Both singe equation and systems estimation procedures were employed to estimate empirical model parameters.

The empirical analysis resulted in a meat slaughtering system. In the case of the slaughtering for mutton equation all signs of the estimated coefficients were consistent with expectations. In the slaughtering for beef and chicken meat equations only some signs of the estimated coefficients were consistent with expectations. The positive relationship between slaughtering for beef and quality of grazing was inconsistent with expectations. This may be attributed to quality of the data available to support specification of a more appropriate indicator of grazing quality. The positive relationship between chicken meat slaughterings and mutton prices were inconsistent with expectations, indicating that these two are not necessarily substitutes but rather complements.

In terms of its size the intercept was the most powerful variable in all equations. Aside from the intercept the real own price the retailer realised over the past five years proved extremely powerful compared to the rest of the variables in the case of the slaughtering for mutton equation. The number of stock kept two years ago also deserves mentioning at about half of the above-mentioned variable's magnitude. In the case of slaughtering for

beef and chicken meat equations the power of variables are distributed more evenly. The price of mutton had the most power in both the slaughtering for beef and chicken meat equations.

In terms of statistical significance the power of variables was evenly distributed in the slaughtering for mutton equation with the average degree of exposure to international trade during the last five years as the most powerful variable. In the case of the slaughtering for beef equation the current real price for mutton producers received for their products and the average seven year effect of the quality of grazing proved more powerful compared to the rest of the variables. In the case of slaughtering for chicken meat the intercept and time trend were extremely powerful compared to the rest of the variables.

Despite its reported system wide R-square of 82 percent Adam's (1998) meat demand system did not give good in sample forecasts. Instead it was decided to account for demand factors indirectly through an auction price system. The empirical analysis resulted in an auction price system where the auction price of mutton depends on the retail price (0.324) and total supply (-0.343); and the auction price of beef depends on disposable income (-0.719), the retail price (0.645), total supply (-0.330) and the effect of time (0.062).

As the auction price system only included mutton and beef, the meat sub-sector model was reduced accordingly. In sample forecasting based on ex post within the sample data applying the dynamic-deterministic simulation of the Gauss-Seidel solution, proved satisfactory and the model therefore adequate to run policy simulation experiments. Two scenarios were tested, namely: (1) increasing mutton imports by 5.9 % every year from 1995 up to 2002; and (2) increasing mutton imports by 100 % every year from 1995 up to 2002. The results illustrated that the short-term impact of increased imports will lead to an increased supply of mutton on the domestic market at decreased consumer prices. Producer prices are expected to follow consumer prices and will accordingly also decrease. Decreased producer prices will result in decreased domestic slaughterings and, finally, increased imports will also decrease the price realised for substitute products. As the meat sub-sector, however, has time to adjust to increased levels of imports, some of the results seem to be surprising. Never the less, even the long-term effects remain negative, in general.

As a long-term solution to improve the results of the policy question at hand it is recommended that both the private and public sector embark on an effort to improve SA's database. In the case of the meat sector a relatively small sample of 30 data points exist, with structural breaks in almost all time series data. For short-term result improvements it is recommended that a number of assumptions made in this study be revisited: (1) alternative or improved econometric estimation techniques in order to include the pork and chicken meat industries, (2) substitution of the auction price system with a demand / consumption system, (3) extension of the product side of the model to al least incorporate land as a production factor and (4) revisiting the validity of applying classical OLS estimation techniques.

1.1 Motivation and purpose of the study

The importation of live animals into South Africa (SA) is permitted for breeding purposes only and not for slaughtering purposes. However, the SA tariff book does not make provision for a distinction between the imports of live animals for breeding purposes and imports of live animals for slaughtering. Different tariffs exist on the importation of meat, while a zero tariff applies for the importation of live animals whether they are imported for breeding or slaughtering. Competing countries see this as a loophole and an opportunity to elude tariffs with regard to carcasses. Other countries, such as the United States of America (USA) and the European Union (EU), make a clear distinction between these two categories.

Since 1995, the importation of live animals for slaughtering purposes has been banned in SA. This ban was based on the Governments' position against the transport of slaughter animals by sea into the country. Shipping animals over long distances causes special problems. It is an archaic method unsuited to modern times. The Department of Agriculture (DA) is of the opinion that slaughtering animals close to their place of origin and transporting the meat using modern refrigeration technology are more acceptable practices.

Although the Department received only one official permit application, increasing interest was shown by various firms to import live sheep for slaughtering purposes from Australia. Despite the above-mentioned viewpoint of the DA, the Directorate of Animal Production and Health (DAPH) has the responsibility, in terms of the provisions of the General Agreement on Tariffs and Trade (GATT), to evaluate the zoosanitary aspects of the importation of any animal products and animal material objectively with respect to possible animal health risks. In response to this permit application, the DAPH subjected all available information to a process of risk analysis in order to determine whether the risk with regard to the intended imports is acceptable. They found that the health risk involved in the direct slaughtering of live sheep imported from Australia is minimal and accordingly acceptable. This included the full spectrum of important diseases and parasites.

In addition to the findings of the DAPH tests and investigations, the Minister of Agriculture and Land Affairs appointed a fact-finding mission to Australia in August 1995 (NAPH, 1995). However, the DA's position did not change and the Minister continued to place an embargo on the import of live animals despite repeated requests and applications received to review the decision and to lift the embargo. This situation, however, could not be sustained indefinitely on non-objective grounds and continues to put pressure on the DA to reconsider its position.

There are two aspects to be considered regarding the imports of live sheep. The first aspect deals with current import regulations (tariff regime) on imports of live animals, while the second aspect deals with the economic implications of such imports.

According to World Trade Organisation (WTO0 regulations, it is possible to create two new tariff lines that can distinguish between imports for breeding and imports for slaughtering. This will depend on whether in the past, imports for slaughtering purposes took place or are currently taking place under the existing tariff line. If this is the case, it will not be easy to create the new lines, especially if it means imposing a new tariff on imports of live animals for slaughtering that is higher than the existing one. This would imply that South Africa has to grant similar concessions to the affected country (e.g. Australia), which have to be negotiated. South Africa has agreed to bind the tariff levels of the existing line at zero per cent, which would prevent the country from imposing a tariff higher than zero on the new lines to be created. If South Africa would want a higher tariff, negotiations will have to take place at a multilateral level within the framework of the WTO, with interested and affected parties and concessions in other areas. Notwithstanding these obligations, this is an option that could be considered in partially addressing the problem.

The government's concern is, however, caused by the second aspect that deals with the economic implications of lifting the embargo. Lifting the embargo on live sheep imports will result in an increased supply of mutton on the domestic market at decreased consumer (retail) prices. Producer (auction) prices are expected to follow consumer prices and will accordingly also decrease. Finally, decreased producer prices will result in decreased domestic slaughterings. The effect of increased imports even extends well beyond that of lower mutton prices and reduced mutton production. It can also be hypothesised that increased imports will decrease the price realised for substitute products such as beef, pork and chicken.

Moreover, increased imports will also impact on factor inputs used in the production of meat. A total of 60% of the land area of South Africa is only suitable for extensive stock farming, making land the single most important input in the production of mutton. Therefore, it is easy to believe that the value of land will decrease because of increased imports. The value of land plays an integral part in sheep farmers' liabilities and accordingly in their ability to acquire credit. Should sheep farms lose their value, farmers will most probably not be able to continue their operations and will have to look for alternatives. This will lead to socio-economic problems, because it is difficult to use the sheep-grazing areas of the country to support the production of other alternative agricultural commodities.

After the risk considerations have been cleared, the DA was forced to evaluate the economic implications of lifting the embargo on the importation of live sheep for slaughtering purposes. The present study is therefore motivated by the DA's interest to address this policy issue.

1.2 Objectives of the study

The overall goal of this study is to investigate the economic implications of importing live sheep for slaughtering purposes on the domestic mutton market. It is assumed that all aspects with regard to the legal framework as well as with regard to the physical capacity, for such imports, are adhered to. Aspects referred to under the legal framework include issues such as sanitary and animal welfare regulations, standards and quality control, international agreements, as well as import and export regulations. Aspects referred to under physical capacity include issues such as harbour, abattoir and transport facilities, support services and supply capacity.

Under this main objective the following specific objectives were pursued to quantify and determine the impact of live sheep imports on the meat sub-sector in terms of:

– domestic slaughterings and consumption
– auction and retail prices
– the value of land in sheep-producing areas

1.3 Approach and methods

In order to address the policy issues raised and achieve the objectives of the study, it is clear that one should consider the various meat-product markets (mutton, beef, pork and chicken) as well as related factor markets, e.g. land. This certainly requires the use of a multi-market model. The model builds on earlier results from research carried out by Adam (1998) on estimation of a meat demand system for SA, as well as on earlier results from research carried out by Van Schalkwyk (1995) on estimation of a production function for the sheep-grazing region of SA. The said research work is extended in this study to develop and estimate a system of meat supply equations to complete the multi-market model.

Discrepancies existed in the data between official and private sector sources. In order for the meat market model to balance, it is extremely important to standardise of either of the sources. Since the demand system of the sector model was based on Adam's (1998) estimations using consumption data supplied by the DAS, this study based, as far as it was possible, the supply system estimation and the rest of its analysis on data supplied by the DAS.

1.4 Organisation and structure of the report

This study is comprised in 6 chapters. Chapter 1 defines the research problem and motives for undertaking the study. A general background of the livestock industry, namely sheep, cattle, pigs and chicken is given in Chapter 2. Chapter 3 reviews current methods of economic policy analysis and defines specific empirical methods for the study. A multimarket model for the meat and land sectors in the country is developed and alternative estimation procedures are discussed in Chapter 4. Chapter 5 presents results of and problems with the specified multi-market model, presents results of the reduced meat sub-sector model and includes policy simulations. A summary of the report, as well as conclusions and recommendations of the empirical analysis and their policy implications are presented in Chapter 6.

Chapter 2 : The meat sub-sector of South African agriculture: significance and performance

Comprehensive and, in certain cases, extremely swift agricultural marketing reforms took place in SA over the last decade. The SA meat industry has undergone fundamental changes in the process of almost total market liberalisation, with dramatic implications for the entire industry. These changes and the practical effects thereof are discussed below (section 2.1). To indicate the importance of the meat industry to the SA economy, the meat industries' contribution to Gross Domestic Product (GDP) and employment is discussed in section 2.2. General information about the meat industries' domestic production, consumption and prices is given in sections 2.3, 2.4 and 2.5, respectively. This chapter ends with a discussion of the global environment, mainly to put the country into perspective with the rest of the world (section 2.6).

2.1 Major policy changes and strategies that influenced the development of the meat industry over the recent past

The deregulation process of the SA meat industry gained momentum in the early 1990s, and was finalised with the dissolvement of the Meat Board in December 1997.

2.1.1 Changes in agricultural policy

In the context of international trends towards market liberalisation, gradual changes took place in the agricultural marketing environment of the country in the period preceding 1996. A shift of emphasis from rigid and strict control measures towards a more market-orientated approach occurred, while internationally accepted rules and norms gained importance. This resulted in, amongst others, the replacement of quantitative import controls with tariffs, the abolition of most subsidies and a re-examination and investigation of the marketing regulations that were still on the statute books.

The 1968 Marketing Act (Commission of Inquiry into the Marketing Act, 1976), which had been instituted mainly in the interest of producers, made provision for various controls with regard to the movement, price setting, quality standards, sale and supply of agricultural products. The philosophy underlying the 1968 Act also clashed with the new government's policy imperatives: efficiency, growth, food security and equity. The Marketing of

Agricultural Products Act (Act No. 47 of 1996) came into effect on 1 January 1997 and introduced a new era in the marketing of agricultural products in the country. One of the main provisions of the 1996 Act was that all the remaining control boards had to be phased out within 12 months. Some partial deregulation had taken place prior to the implementation of the 1996 Act and some Schemes had already been revoked before 1997 (e.g. bananas, dried beans, eggs, chicory, rooibos tea and tobacco).

In terms of the 1968 Marketing Act, the Minister could introduce an intervention (a statutory measure) only if it had the proven support of a specified majority of producers. The 1996 Act, on the other hand, determines that any directly affected group can request an intervention. However, the Minister may only approve such a statutory measure where he or she is satisfied that it will advance one or more of the objectives of the 1996 Act without being detrimental to one of the other aims, food security, work opportunities in the economy, or fair labour practices. To date statutory measures in respect of records and returns, and registration have been introduced in the maize, winter cereals, oilseeds, cotton, wine, wool and sorghum industries, while levies were introduced in the winter cereals, cotton, wine and sorghum industries. At this stage the red meat industry has not applied for any of the statutory measures provided by the 1996 Act and therefore operating free of any marketing control measures.

2.1.2 Deregulation in the red meat industry

The Meat Scheme in existence at the time of the promulgation of the 1996 Marketing Act, was publicised in the *Government Gazette* (1991). The Meat Scheme made provision that the Board performs the following functions:

- Operating a single-channel marketing system for slaughter animals, meat, offal and hides and skins
- Operating of a floor price system
- Conducting of offal pools
- Issuing of permits for the purchase and sale of slaughter animals, meat, offal and hides and skins
- Providing an information service
- Promoting the consumption of red meat

2.1.2.1 The single-channel marketing system

In the early 1990s the Meat Scheme made provision for so-called controlled and uncontrolled areas. In practice, this meant that only live animals could enter the seven major consumer centres or controlled areas. After the animals were slaughtered at the large city abattoirs, most of the provision of carcasses took place through the eleven public auctions at these abattoirs.

On 22 January 1993 the Minister for Agriculture approved that the Meat Scheme be amended to repeal the prohibition regulations imposed in terms of the Meat Scheme and the Marketing Act, 1968, with regard to slaughter animals, meat, offal and hides and skins. This repeal led to the abolition of restrictions regarding the movement and method of sale of slaughter animals and red meat products.

With the abolition of the controlled areas, a shift occurred in livestock slaughter patterns – from the consumer centres (city abattoirs) to the areas of production (the rural areas). This resulted in the erection of a large number of small and medium-sized abattoirs in production areas. This growth created a major oversupply concerning slaughter capacity – mainly in the big consumer centres or city abattoirs. The reduction in throughput at the city abattoirs led to the closure of a few big abattoirs, most notably the City Deep abattoir in Johannesburg in May 1998.

During the era of deregulation the abattoir sector essentially only offered a slaughter service at a fee. In order to gain a competitive edge in the deregulated environment the focus has shifted. Today the abattoir sector fulfils a totally integrated wholesale function by sourcing from farmers animals on the hoof and directly selling carcasses and meat cuts to the retail sector, thereby shortening the marketing chain.

The deregulation of control over the movement of livestock and meat in 1993 coincided with a rapid growth in the so-called informal market, characterised by the slaughter of livestock outside registered or approved abattoirs, followed by own consumption or direct selling to consumers. Quality control problems inevitably occur in this situation, which could have negative implication for consumer perceptions of red meat.

2.1.2.2 Floor price system

Since the 1950s the Meat Board has operated a system of floor prices for cattle, sheep, goat and pig carcasses. This system was repealed in 1993.

2.1.2.3 Conducting offal pools

The Meat Board conducted offal pools in terms of the Meat Scheme. However, this stipulation was scrapped on 5 November 1993 and the offal pools were sold to Abakor Ltd.

2.1.2.4 Classification and inspection service

The Meat Board performed the meat classification and inspection service at 42 abattoirs. Meat classification and inspection in order to ensure a healthy product for consumers were regarded as important functions. These functions were assigned to the Board by the DA.

2.1.2.5 Meat Board as the sole importer of red meat

Until 1992, the former Meat Board acted as the sole importer of meat. In order to comply with the requirements of the GATT, import control as executed by the Meat Board, was abolished.

2.1.3 Current structures in the red meat industry

2.1.3.1 Meat Board

In terms of the provision of the Marketing of Agricultural Products Act, 1996, the Meat Board terminated its operational activities on 31 December 1997. Up to its dissolvement the Board was funded by means of a compulsory statutory levy on meat and meat products. The Meat Scheme is, however, still in place, mainly for the purpose of finalising outstanding court cases.

2.1.3.2 Red Meat Research and Development Trust (RMRDT)

Before the establishment of the RMRDT, the Meat Board, on behalf of the meat industry, entered into research contracts. Subsequently an amount of R15 million was reserved for this purpose in a Research Trust, which was approved by the Minister of Agriculture late in 1993. The RMRDT was formally established on 21 January 1997.

2.1.3.3 Meat Industry Trust (MIT)

On 31 March 1998, the Minister approved the establishment of the Meat Industry Trust and that an initial amount of R1 million be transferred to it. The Deed of Trust stipulates that the Minister and the meat industry could each appoint 3 trustees. Since the establishment of the Meat Industry Trust, it has been approved that a further amount of R38 million be transferred to it from the Meat Board. The same trustees administer both the RMRDT and the MIT.

2.1.3.4 Meat Forum

The Meat Industry Forum was formed as a result of the promulgation of the 1996 Act. The Forum claims that it has been successful in having the most representative organisation for each sector of the industry, on the Forum. Any national organisation or association satisfying the criteria of representativeness (which could demonstrate majority support in a particular sector) can apply for membership of the Forum.

2.1.3.5 The South African Meat Industry Company (SAMIC)

In 1997 concerned role-players in the red meat industry established a Section 21 Company (in terms of the Companies Act) to act as the national representative structure of the South African meat industry, managed through its democratically elected Board of Directors. In its implementing role, SAMIC's strategy focuses on the provision of services to meet its stated objectives and will:

– Be the custodian of the SA meat industry;

- Unify the strategic initiatives of all industry role-players by promoting effective communication and coordination of their efforts;
- Be efficient in the provision of specific basic services required by the industry.

SAMIC's vision is to promote the long-term global success of the South African meat industry. It is funded through grants from the MIT and services that are rendered on a user-pay basis.

2.2 Economic importance of the red meat sub-sector

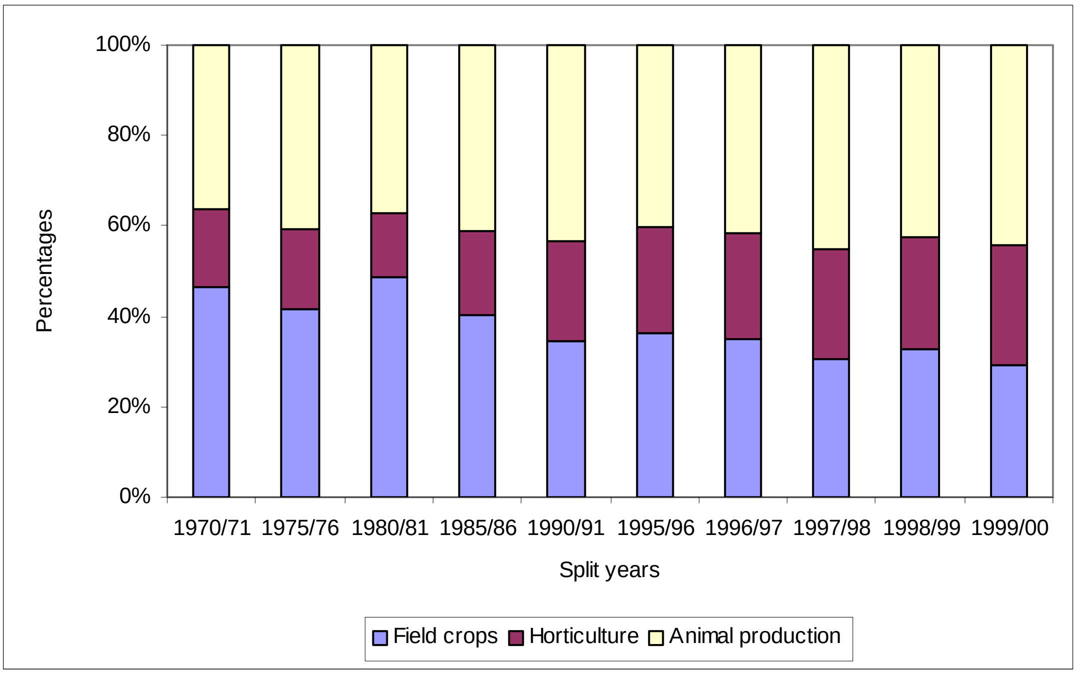
The country covers an area of 1 220 088 km^2 of which approximately 84% is used for agriculture and forestry. Approximately 80% of this area comprises natural veld, which varies from semi-desert vegetation to the highly productive grasslands of the high-rainfall areas.

2.2.1 The meat industry's contribution to GDP

Comparing the meat industry as a whole to the rest of agricultural production, Figure 2.1 depicts the importance of the meat industry. It shows that the contribution of animal products to the gross value of agricultural production, as a percentage, remained the highest since 1985/86 in comparison to field crops and horticulture. This can be attributed to recurrent droughts during the 1980s, causing producers to diversify towards livestock production (Venter, 2001).

Apart from being the biggest contributor to agricultural production (43% of gross value), animal production serves as an important income stabiliser for extensive field crop production (Standard Bank, 2000).

Figure 2-1. Contribution of the main agricultural sectors as percentage of the total agricultural production in SA for 1970/71 to 1999/00 (% of total)



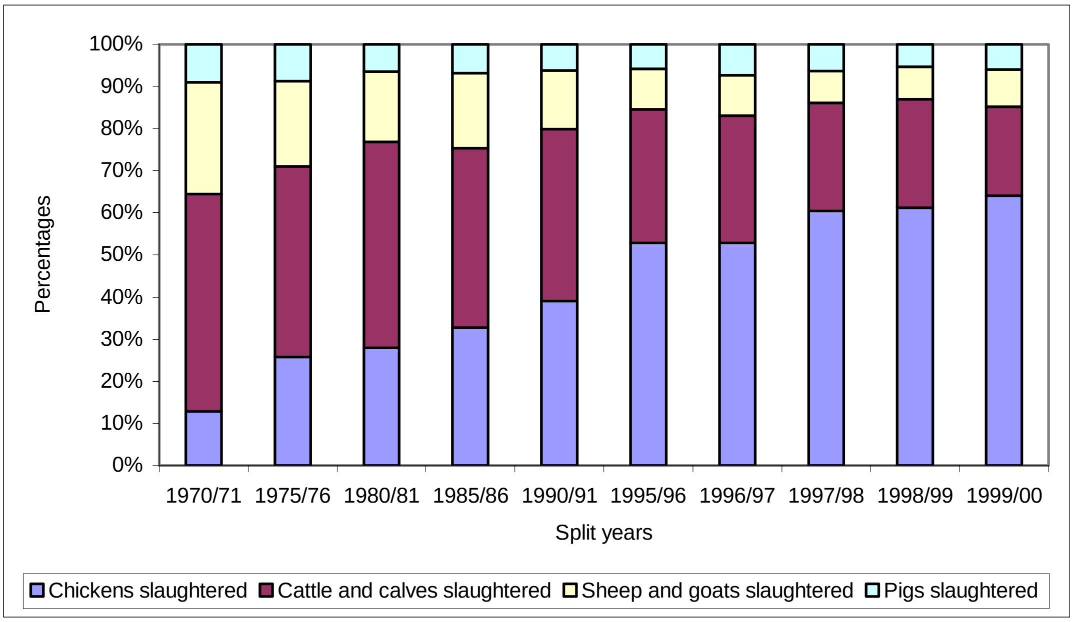
Source: DA, 2001

To indicate the importance of individual animal products, Figure 2.2 shows the gross value of the main animal products as a percentage of the total animal production value. By the year 1995/96, gross value of slaughtered chicken surpassed that of cattle and calves. The pig sector's contribution remained relatively stable over the entire period under review, while the sheep sector's contribution declined. This is confirmed in Figure 2.5 to Figure 2.8. Amongst others, these figures illustrate the trend of slaughterings in comparison to the nominal price realised for the meat products. It is evident from these figures that mutton and beef slaughterings decreased; that pig slaughterings basically stayed constant; and that chicken slaughterings increased.

It is a worldwide trend that pork and chicken meat production is expanding to the detriment of mutton and beef production. South Africa is no exception. Firstly, feed turnover ratios for chicken meat are much higher than for the other meat types. For mutton, beef, pork and chicken meat, feed turnover ratios are, respectively, 1:5, 1:7, 1:3.7 and 1:1.9 (Feedlot norms). Secondly, there are no physical barriers limiting expansion in pork and chicken meat production (because of intensive production), while the opposite is the case in mutton and beef production (because of mainly extensive production). Thirdly, consumers' preferences changed in favour of white meat types (refer to Figure 2.9). Poonyth *et al.*

(2001a) confirmed this in their study that analysed and measured changes in consumers' preferences for meat and consequent meat demand adjustments.

Figure 2-2. Contribution of the main animal products as percentage of the total animal production for 1970/91 to 1999/00 (% of total)



Source: DA, 2001

2.2.2 The meat industry's contribution to job opportunities

Directly, agriculture contributes less than 4% to the country's GDP, while the sector employs approximately 13 % of the economically active population (NAMC, 2001).

In 1999 the DA undertook a case study based on a mail survey to some commercial farmers to obtain up-to-date information regarding the employment situation in agriculture. Their findings are summarised in Table 2.1 (www.nda.agric.za):

Table 2-1. Impact of deregulation on job opportunities in the red meat industry – 1998/99 compared with 1994/95

	Total (%)	Animal (%)	Field Crops (%)	Horticulture (%)
Regular workers	-7.6	-14.4	-6.1	+1.2
Family workers	-5.3	-27.6	-5.3	+9.5
Seasonal workers	+3.4	-9.3	+6.3	+17.3
Contract workers	+28.7			

Source: DA, 1999

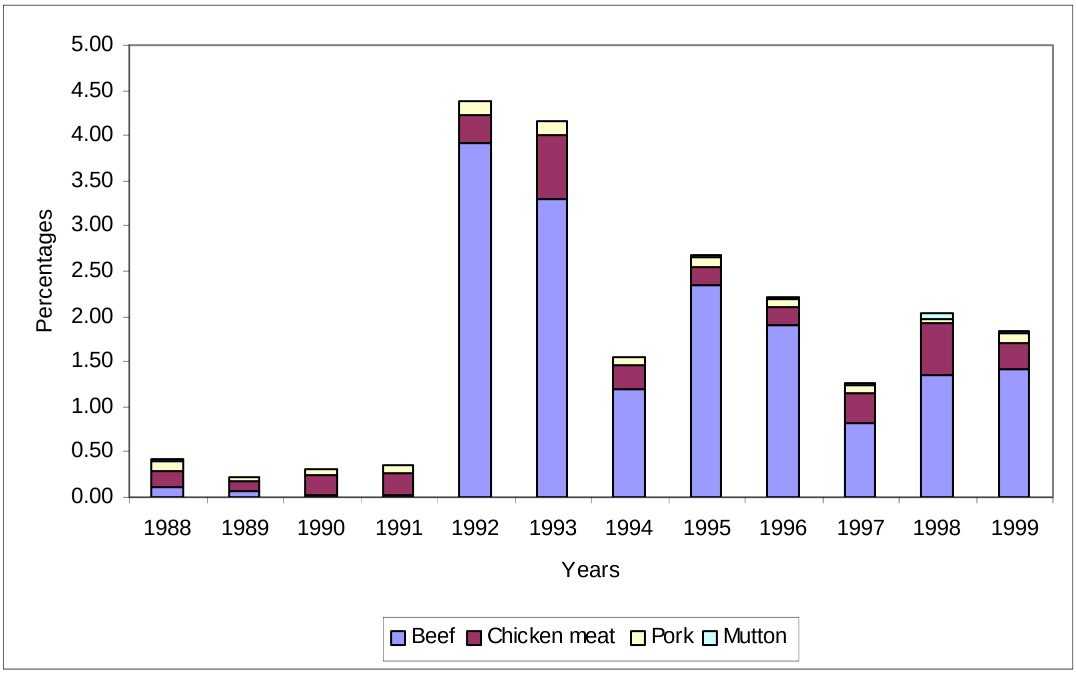
It is evident that commercial farmers involved in animal production shed the largest number of workers. There could be a number of reasons for this, which include the following:

- Labour legislation against the background of a free market economy and a globalised world in which the producer must compete.
- Low prices for meat products (real producer prices for cattle and pigs were, respectively, 15.5 and 20.1% lower than ten years ago while that of sheep remained more or less the same).
- The total of slaughterings of cattle, sheep and pigs were the lowest in 100 years.
- Output prices increased at a slower rate than input prices (the so-called "cost-price squeeze" phenomenon).

2.2.3 The meat industry's contribution to export earnings

SA is mainly a meat importing country and therefore foreign exchange earnings are low. On average (1988 to 1999), 1.78% of export earnings were generated through the meat industry. From meat exports, Figure 2.3 illustrates the meat industry's percentage contribution to total agricultural export value for 1988 to 1999. The clear break before and after 1992 was caused by the fact that Customs and Excise (the original source of import and export data) changed from a hand system to a computer system in 1992 (Heyns, 2001). Data capturing improved because of this.

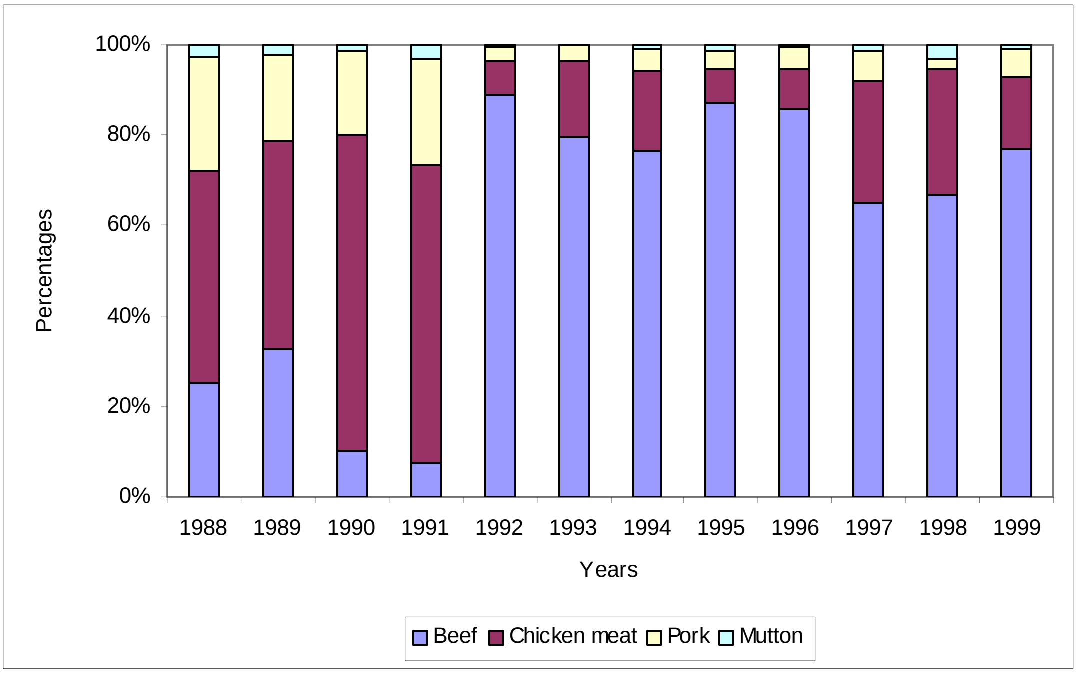
Figure 2-3. Meat industry's percentage contribution to total agricultural exports value for 1988 to 1999



Source: DAS, various issues

On average the meat contribution of (1988 to 1999) mutton, beef, pork and chicken meat to foreign earnings was, respectively, 1.43, 58.52, 10.23 and 29.83% of the total export value of meat. Figure 2.4 supplies each meat industry's export value as a percentage of the total meat export value. Prior to 1992 chicken meat dominated the contribution to the total meat export value, but thereafter the dominant contributor changed to beef.

Figure 2-4. Individual meat industries' percentage contribution to total meat exports value for 1988 to 1999



Source: DAS, various issues

2.3 Domestic supply of meat

Rainfall plays a major role in terms of the quantity of mutton and beef being supplied from local sources, because the availability of pastures and the cost of feed are the major determinants of supply in the meat industry (Willemse, 1999b).

Farmers tend to liquidate their sheep flocks and cattle herds in times of drought, leading to an increase in the number of sheep and cattle slaughtered and a decrease in the national flock (and herd), resulting in an increase in supply and depressed prices. This is known as the production phase and can be seen in Figures 2.5 and 2.6 with the critical drought of 1992 to 1994. Ample meat supplies were experienced and despite the abolition of import control in 1992, no immediate imports occurred.

The herd-building phase is characterised by high rainfall, lower slaughtering and therefore better prices. Farmers tend to hold back cattle during good rainfall periods, mainly because veld conditions are favourable, allowing them to rebuild their cattle herd. In Figures 2.5 and 2.6 the sharp increase in meat prices during 1994 on account of herd rebuilding, is evident. A strong upsurge in the volumes of meat imports was also induced.

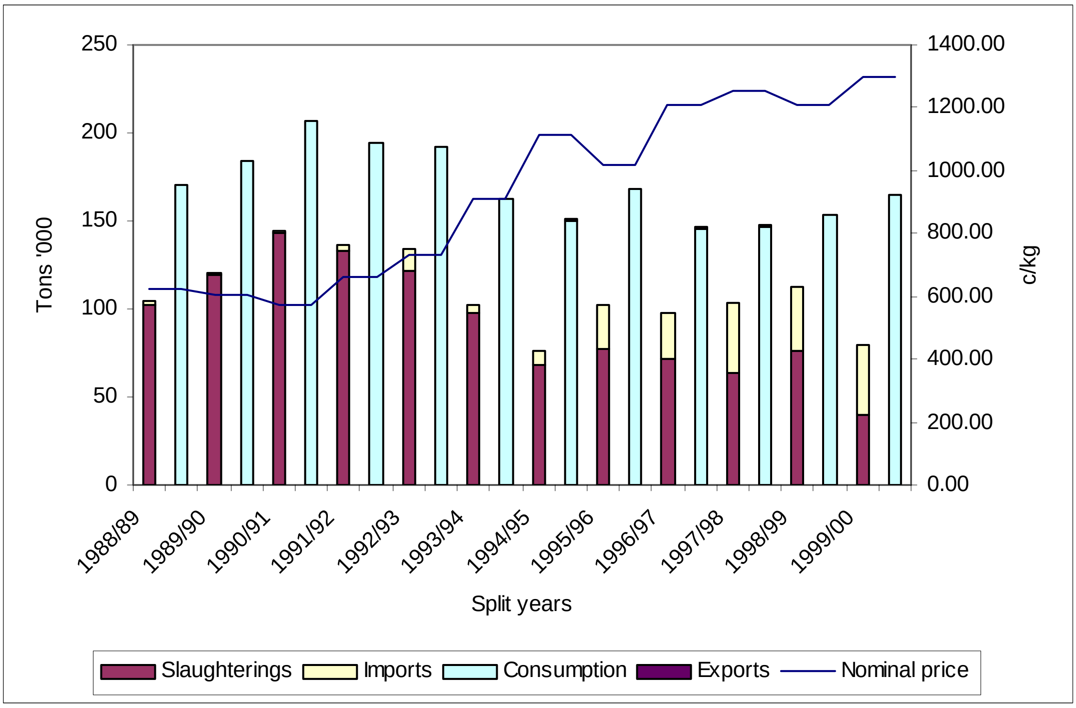
Although the tariff free importation of livestock and meat from Namibia and Botswana had been a frequently occurring phenomenon for more than a century, meat imports from outside the South African Customs Union (SACU) became an integral part of the industry. Apart from SA, the SACU comprises Namibia, Botswana, Swaziland and Lesotho.

Mutton imports from foreign countries constituted between 30 to 50% of total domestic availability, mostly from Australia in the form of frozen mutton carcasses from wool sheep (Standard Bank, 2000). For recent years Figure 2-5 confirms this. Although imported mutton competes with domestic Class C mutton that is of lower quality, domestically produced mutton is still very sensitive to imports, because mutton's domestic auction price is higher than the import price. Various reasons could be given for this, the most important of which is the fact that mutton imported (primarily from Australia) is a by-product of the wool industry. Meaning that this product does not have high value and can be exported at extremely low prices.

Despite decreasing mutton production (sheep slaughterings) in both the formal and informal markets, consumption is increasing (as from 1989) because of the increase in imports, as well as shifts in tastes and preferences caused by lower relative prices.

Sheep and cattle stocks show the same trend, however, it should be noted that stock theft and pests/predators (mostly jackal and lynx) are the main causes behind the decrease in sheep numbers in recent years.

Figure 2-5. Mutton trade balance for 1988/89 to 1999/00

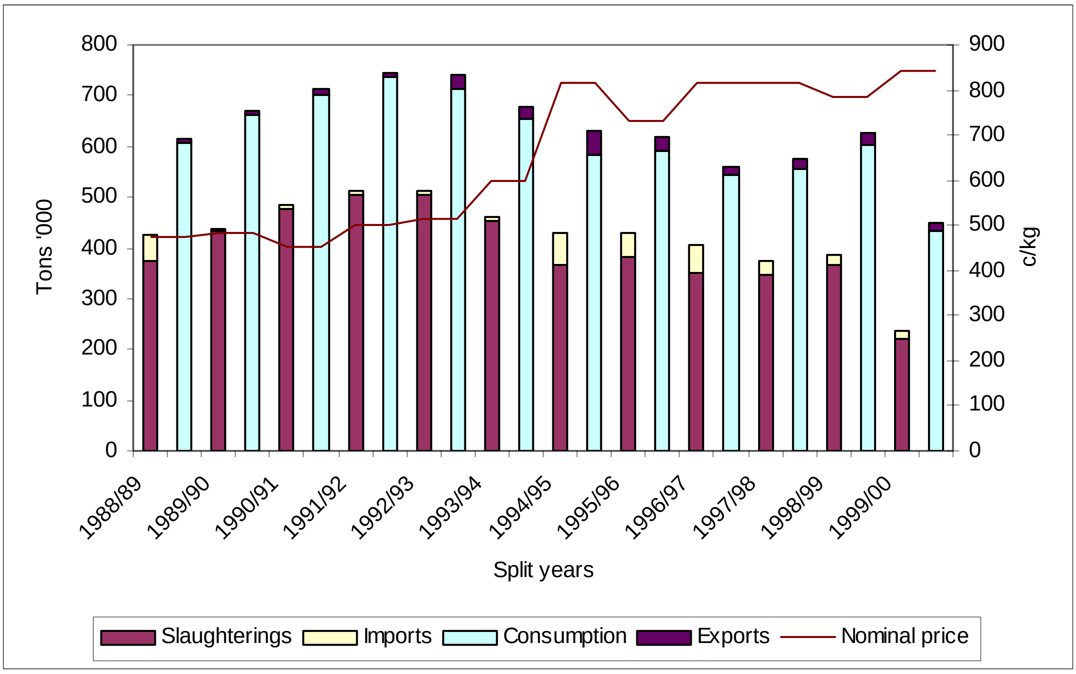


Source: *SAMIC and DAS*, various issues

Figure 2.6 shows the availability of beef on the market for 1988/89 to 1999/00. Beef is, mainly, imported from the EU, but also from outside SACU (Standard Bank, 2000). These imports compete directly with Class C beef on the domestic market. This imported beef normally is used for meat processing, and as such does not directly compete in the fresh beef market. A special tariff rebate exists whereby beef imported for certain types of processing can be cleared at a zero tariff. As in the case of mutton, the strong upsurge in the volumes of beef imported in 1995, induced a sharp decline in prices (Willemse, 1995).

As a result of the envisaged establishment of a Free Trade Agreement (FTA) between South Africa and South America's large and generally low-cost meat producers, imports from Brazil, Argentina and Uruguay are expected to increase considerably. Consumption in the South American countries is, also, already on a relatively high level, and they generally have foot-and-mouth-disease-free status.

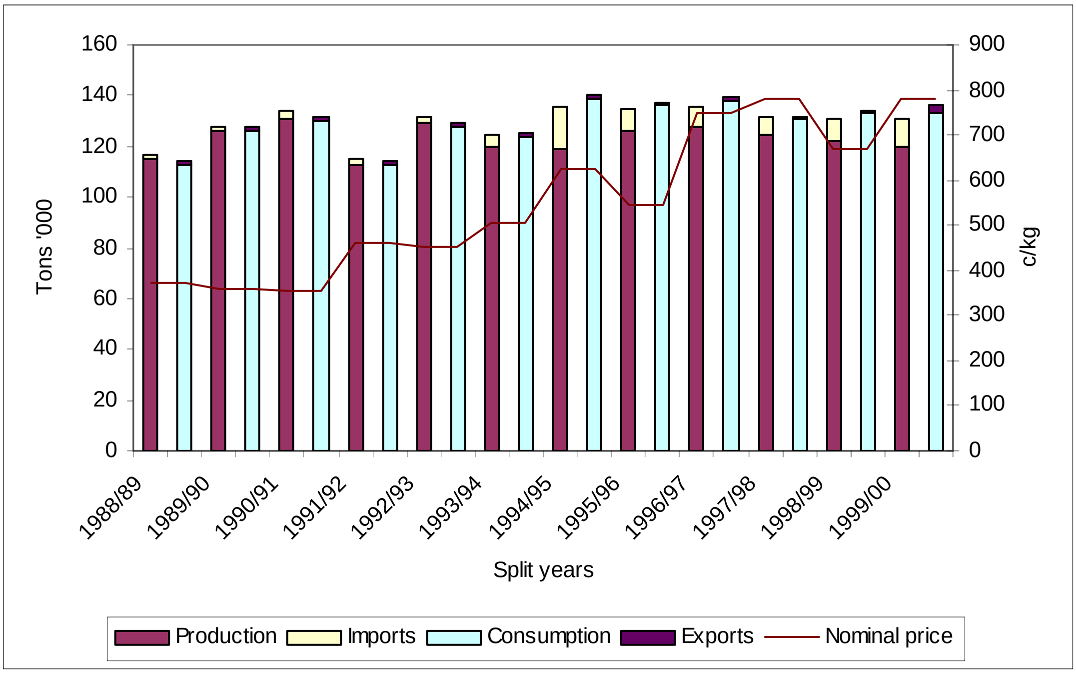
Figure 2-6. Beef trade balance for 1988/89 to 1999/00



Source: *SAMIC and DAS*, various issues

Figure 2.7 shows the availability of pork on the market for 1988/89 to 1999/00. Pork is the only meat type where production stayed relatively constant over the years. When pork production is expressed in terms of per capita production, it is evident that production increases over the years responded to population increases (Venter, 2001). Pork production is therefore known to adjust successfully to increased consumer needs. As is the case with mutton and beef imports, pork imports have also increased substantially since 1994/95. These imports, mainly from the EU and Hungary, consist of spare ribs and fat of which South Africa is unable to produce enough to satisfy domestic demand (Standard Bank, 2000). Neighbouring countries are not allowed to export pork to SA because of the existence of swine fever in the region, but other important countries from which SA imports are the United Kingdom, France and Canada.

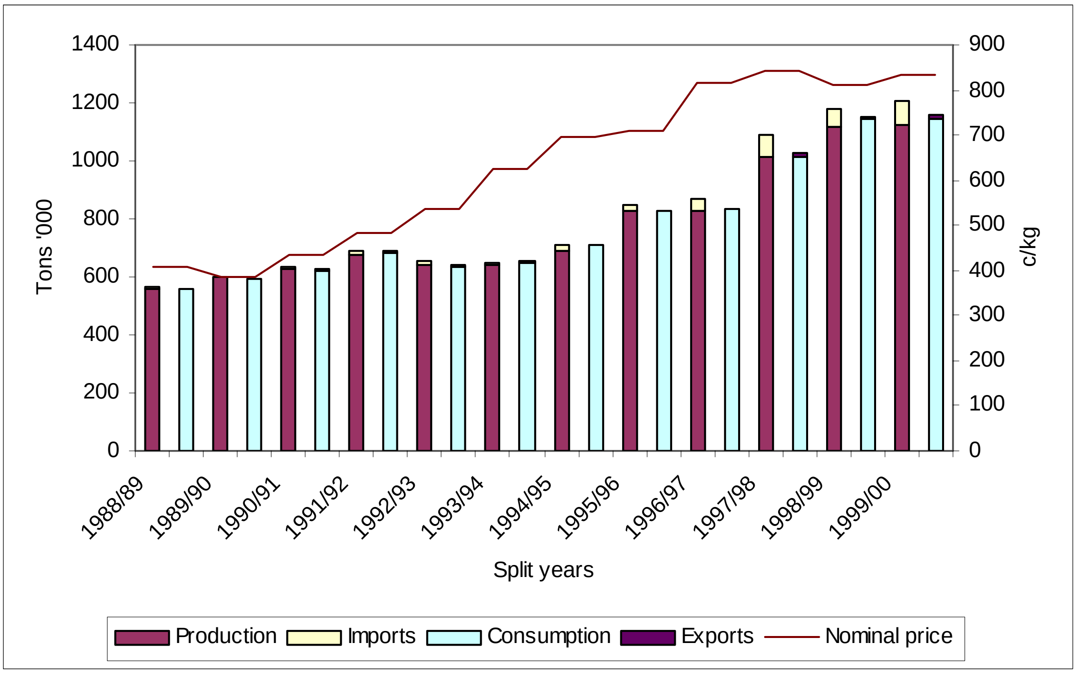
Figure 2-7. Pork trade balance for 1988/89 to 1999/00



Source: *SAMIC and DAS*, various issues

Figure 2.8 shows the availability of chicken meat on the SA market for 1988/89 to 1999/00. Consumption and production have shown an increasing trend since 1993/94 and are currently at the highest recorded levels. Foreign imports of chicken meat have soared since 1997/98, coming mostly from the USA, Brazil and Canada. SA imports mainly chicken portions, for which there is not a strong demand in the USA (Willemse, 2000). Because of the Americans' preference for breast meat only, chicken portions are a surplus product in the USA and end up on the SA market far below the domestic producer price. As in the case of mutton, the domestic market is very sensitive to imports. Despite the country's sensitivity towards chicken meat imports, the production thereof increased considerably. This can be explained by Figure 2.9 (illustrating the per capita consumption of meat), where the per capita consumption of chicken meat soared over the other meat types.

Figure 2-8. Chicken meat trade balance for 1988/89 to 1999/00



Source: *DAS*, various issues

2.4 Consumption

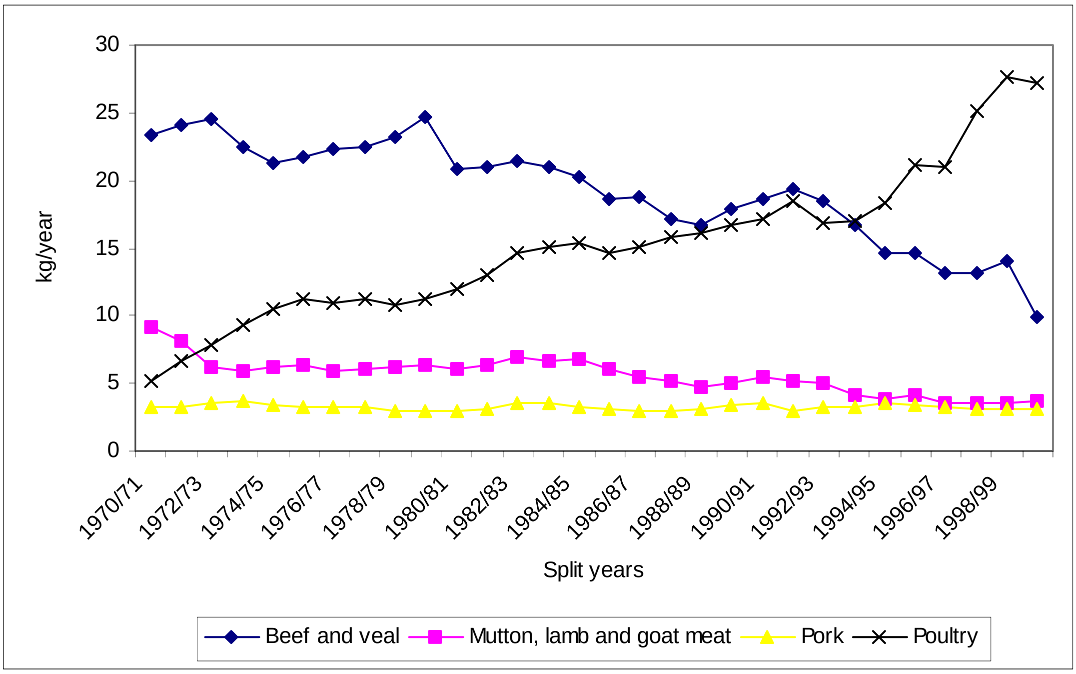
Income distribution, as well as levels of urbanisation has changed as a result of the fundamental political changes that recently took place in the country. For example, access to better education, health and other basic services for large numbers of previously disadvantaged citizens has increased. As a result, the structure and patterns of consumption have changed significantly.

2.4.1 Per capita consumption

Figure 2-9 shows the per capita consumption of meat for 1970/71 to 1999/00. Per capita consumption of mutton and beef declined while per capita consumption of chicken meat increased and that of pork stayed relatively constant. Laubscher (1990) identified a declining trend in the market share of red meat compared to white meat while Lubbe (1992) indicated that the per capita consumption of red meat showed a continuous decline throughout 1951 to 1990.

The World Bank (1993) reported that the total consumption of meat has grown at a much faster rate in developing countries than in industrial countries. In developed countries consumption continued to shift towards poultry at the expense of both beef and pork. In developing countries, except Africa, the per capita consumption of meat rose slightly with a continued shift towards pork and chicken meat at the expense of mutton and beef [Food and Agricultural Organisation (FAO), 1994]. The reason for the decline in beef and veal consumption in other regions of the world varies in different countries. These include health concerns, aging population and stagnating household incomes.

Figure 2-9. Per capita consumption of meat for 1970/71 to 1999/00



Source: *DAS*, various issues

Several factors contributed to the decline in per capita consumption of red meat. According to Lubbe (1992), one of the major reasons was probably the failure of the red meat industry to adjust to changes in the socio-economic consumer environment. It did not compensate for the trend in urbanisation because it was designed primarily to serve the needs of urban white consumers. Policies and restrictions such as supply control, the floor price system etc. also effectively restrained the adjustment process (Lubbe, 1992). Poonyth *et al.* (2001a), in fact, hypothesised and tested that the reason for recent shifts in meat consumption trends is the result of income redistribution and the consequent adjustments in preferences for different meat products.

2.4.2 The relationship between consumption and income

According to the University of the Orange Free State (2000) and the World Bank (1993) there is a positive relation between consumption of beef and income. The relationship is, however, nonlinear and at a certain income level consumption tends to stabilise and then declines at higher incomes. Income levels also affect the types of meat required, with a greater demand for more expensive cuts as income increases. It can be postulated from this, that reduced growth in income in major markets will depress the demand for meat. In low-income countries, increases in per capita income, urbanisation and changes in relative prices have been the main determinants of a higher per capita demand for meat. In high-income countries, factors other than income have become important in determining consumption patterns. These factors include diet and health concerns, increasing demand for convenience foods and changes in demographic features.

In South Africa the demand for meat is highly sensitive to changes in per capita income. This is mainly because the high-income elasticity of meat products (Liebenberg & Groenewald, 1997).

2.5 Meat price cycles, relationships, formation and differentials

Persistent low profit margins in the livestock industry since the 1980s, together with the upsurge in imports in the 1990s led to a constant decline in real producer prices of meat, which had critical financial effects on the industry in the deregulated market.

SA represents a classic example where the levels of macroeconomic activity (specifically GDP) primarily influence the level of domestic producer prices of meat (Standard Bank, 2000). According to Willemse (1999a) prices for meat producers depend very strongly on economic growth (domestic as well as international). When the economy is growing, consumers' ability to spend improves, which will stabilise the demand for meat products and improve their prices. On the other hand, the exchange rate also plays a major role. When the value of Rand deteriorates, import prices increase and export prices decrease, which is to the benefit of the local producers.

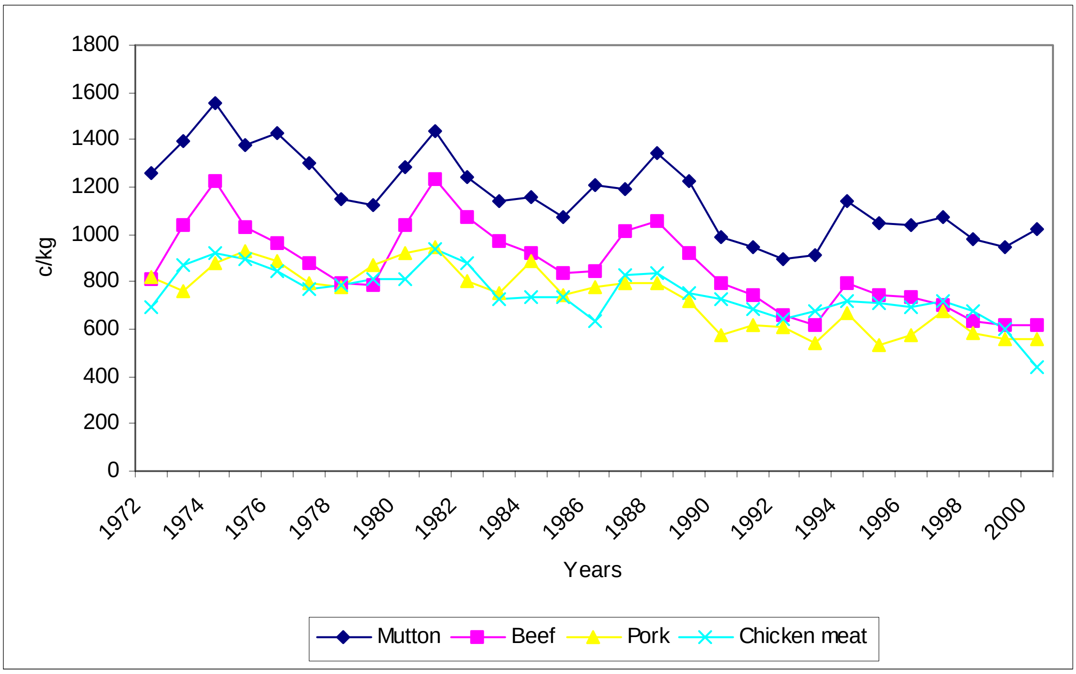
2.5.1 Price cycles and interrelationships in the meat sub-sector

According to Van Heerden et al. (1988a, 1988b), there is a great degree of mutual dependence between meat prices. Beef is the price leader to all meat prices taking more than a month to adapt fully to changes in market conditions. Mutton, pork and chicken meat prices tend to move closely with beef prices.

Figure 2-10 illustrates the price cycles in mutton, beef, pork and chicken meat. Prices were adjusted with the consumer price index (CPI) as published in the Abstract of Agricultural Statistics (DAS, 2003), to exclude the effect of inflation from the price variation. A seven-year price cycle is clearly visible. Five years of real price declines were recorded from 1974 to 1979, followed by two years of real price increases. Again four years of declining prices from 1981 to 1985 were followed by three years of real price increases. This trend continued until an interruption occurred in 1995. In 1995 the typical seven-year price cycle was broken as a result of the upsurge in meat imports (refer to Figure 2.5 to Figure 2.8), resulting in the expected second year of real price increases to actually change to real declines. Prices have been declining ever since.

It should, however, be noted that the price cycle for pork is shorter than that identified for mutton and beef. This is due to the fact that the reproduction cycle of pigs is much shorter. Although pork is mostly produced under intensive fattening, it is not possible to smooth reproduction cycles (in an attempt to smooth price cycles), as its' price is interdependent on the other meat prices. What is interesting from Figure 2-10 is that the price of beef forms a sort of a ceiling for the price of pork. In the case of chicken meat prices, it is evident that the price cycle is even shorter than in the case of pork, but that prices tend to follow the same trend as beef prices.

Figure 2-10. Real producer prices of mutton, beef, pork and chicken meat for 1972 to 2000



Source: *DAS, 2003*

From the consumers' point of view; mutton, beef, pork and chicken meat are all substitutes of one another (refer to section 2.4.1 for a more detailed discussion). From the producers' point of view the relationships between mutton, beef, pork and chicken meat are not as clear. If one is, for example, a mutton producer (farming extensively with sheep), alternatives to production are extremely limited (Venter, 2001). The same will be the case for beef, pork and chicken meat producers. One could reason, however, that mutton and beef are both produced extensively (in most cases) and would make easier substitutes. The same reasoning can be used to say that pork and chicken meat are both produced intensively (in most cases) and would therefore also make easier substitutes. Time will also play an important role in the producers' decision-making problem. In the short term, a mutton producer may decide to produce mutton instead of beef, but in the long run he/she may decide to change to pork or chicken meat production. Hides and skins are the only straightforward complementary products to, respectively, beef and mutton. Wool, on the other hand, is normally regarded as a complementary product. It is estimated that only 30 % of producers' (farming with sheep – meat and wool) income is generated through wool, which means that wool is merely complementary to mutton (Venter, 2001). The relationship between wool and mutton can, however, change to being supplementary under situations where the price realised by good quality wool increases to 50 %.

2.5.2 Price formation

The rapid growth in the number of registered abattoirs and accompanying vertical integration of animal sourcing to direct selling of the value-added product to retailers or customers, changed the red meat trade from a predominantly auction market to a private on the spot selling/buying and forward market. This eroded the red meat industry's price information base, which impacted negatively on especially extensive producers because it has become difficult at the time of selling to assess representative indicator prices on a quality differentiated basis.

2.5.3 The price differential between the producer and retailer

Agriculture became exposed to international trade in the early 1990s. In theory, tariff-free imports stabilise the market for consumers of agricultural products, who benefit from goods bought at the lowest prices available on international markets. This situation is aggravated by the greater support that the country's competitors get from their governments. In 1998 farmers in the EU and USA received 45 and 22 %, respectively, of their income from various forms of government support [National Agricultural Marketing Council (NAMC), 2001]. Also contributing to the gap between producer and consumer prices could be value adding, which was done to products beyond the farm gate. The following tables illustrate the widening of the gap between producer and consumer prices in the past decade.

Table 2-2. Annual producer and consumer prices of mutton for 1992 to 1999 (c/kg)

	Nominal producer price (c/kg)	Real producer prices (c/kg)	Slaughter-ings (kg)	Nominal consumer prices (c/kg)	Real consumer prices (c/kg)	Producer share in consumer prices (%)	Consumer price index
1992	687.8	523.8	8 026 820	1 452.0	1 105.9	47.37	131.3
1993	774.2	537.3	7 147 386	1 596.0	1 107.6	48.51	144.1
1994	1 048.0	667.5	5 014 825	2 041.0	1 300.0	51.35	157.0
1995	1 047.3	613.9	4 550 208	2 259.0	1 324.2	46.36	170.6
1996	1 112.5	607.3	4 834 360	2 320.0	1 266.4	47.95	183.2
1997	1 253.4	630.2	4 064 573	2 519.0	1 266.5	49.76	198.9
1998	1 216.4	572.2	4 475 000	2 503.0	1 177.3	48.60	212.6
1999	1 236.4	550.4	4 872 077	2 568.0	1 132.1	48.15	225.3

Source: NAMC, 2001

Real producer prices for mutton remained on basically the same level as nine years ago. Real consumer prices, however, increased by approximately 7.3 %. The result is that the producer share of the consumer prices fluctuated between 51.4 and 46.4 %. The large gap between producer and consumer prices is not a unique situation to mutton and represents the cost of getting the slaughtered carcass to the consumer (Venter, 2001). It is also interesting to note that slaughterings of sheep have decreased by more than 44% since 1992 up to 1999.

Table 2-3. Annual producer and consumer prices of beef for 1992 to 1999 (c/kg)

	Nominal producer price (c/kg)	Real producer prices (c/kg)	Slaughter-ings (kg)	Nominal consumer prices (c/kg)	Real consumer prices (c/kg)	Producer share in consumer prices (%)	Consumer price index
1992	504.3	384.1	2 438 389	1 191.0	907.1	42.34	131.3
1993	521.9	362.2	2 393 263	1 255.6	871.3	41.57	144.1
1994	728.3	463.9	1 918 045	1 556.0	991.1	46.81	157.0
1995	746.8	437.7	1 771 569	1 742.0	1 021.1	42.87	170.6
1996	785.5	428.8	1 763 671	1 784.0	973.8	44.03	183.2
1997	820.8	412.7	1 567 635	1 899.0	954.8	43.22	198.9
1998	792.5	372.8	1 750 000	1 895.0	891.3	41.82	212.6
1999	812.0	368.4	1 907 785	1 966.1	880.6	41.30	225.3

Source: NAMC, 2001

The constant decline in real producer prices for beef (from 435.8 c/kg in 1991 to 368.4 c/kg in 1999) is evident from the above table. It is quit clear that the cattle producer is in a much weaker position than 9 years ago.

Table 2-4. Annual producer and consumer prices of pork for 1992 to 1999 (c/kg)

	Nominal producer price (c/kg)	Real producer prices (c/kg)	Slaughter-ings (kg)	Nominal consumer prices (c/kg)	Real consumer prices (c/kg)	Producer share in consumer prices (%)	Commer-cial sow herd
1992	467.0	355.7	2 049 401	979.0	745.6	47.70	124 206
1993	455.4	316.0	2 020 027	1 044.3	724.7	43.61	122 426
1994	617.7	393.4	1 815 452	1 238.0	788.5	49.89	110 027
1995	531.0	311.3	1 922 583	1 333.0	781.4	39.83	116 520
1996	621.5	339.2	2 034 575	1 345.0	734.2	46.21	119 681
1997	789.6	397.0	1 846 517	1 559.0	783.8	50.65	108 619
1998	724.9	341.0	1 870 000	1 598.0	751.6	45.36	110 000
1999	705.8	288.5	1 851 993	1 524.0	710.2	46.31	100 000

Source: NAMC, 2001

The real producer prices as well as the producers' share in consumer prices of pork declined during the past nine years while the real consumer prices increased over the same period.

Table 2-5. Annual producer and consumer prices of chicken meat for 1991 to 1999 (c/kg)

	Nominal producer price (c/kg)	Real producer prices (c/kg)	Produc-tion (1000 kg)	Nominal consumer prices (c/kg)	Real consumer prices (c/kg)	Producer share in consumer prices (%)	CPI
1992	493.8	376.7	563 550	734	559.9	67.28	131.3
1993	573.8	398.2	531 540	790	548.2	72.63	144.1
1994	662.7	422.1	525 980	936	596.2	70.80	157.0
1995	713.5	418.2	567 307	1 009	591.4	70.71	170.6
1996	740.4	404.2	677 344	1 075	586.8	68.88	183.2
1997	838.8	421.7	680 000	1 173	589.7	71.51	198.9
1998	851.6	400.6	833 745	1 219	573.4	69.86	212.6
1999	799.5	354.9	916 594	1 196	530.8	66.85	225.3

Source: DAS and SAPA, various

Compared to 1992, the real producer prices as well as the producers' share in consumer prices of chicken meat declined during the past nine years. Chicken meat is the industry with the highest producer share in consumer prices (62.06% on average for the nine years from 1992 to 1999).

2.6 The global environment for meat

2.6.1 South Africa in perspective

According to De Jager (1996a), in comparison with SA, developed countries have a larger population, as well as bigger economies. The EU (SA's biggest trading partner in general, but especially in beef) has ten times as much people, but its economy is 60 times bigger. Australia (SA's biggest trading partner in mutton) has less than half our population, but its economy is at least three times larger. China is the world's biggest potential consumer of meat, because its population is very large, more than a quarter of the world population, and because its economy is growing at a very fast rate.

In terms of production, one third of the world's beef is produced in the USA and the EU. In global terms, more pork is produced than beef and mutton together. SA produces 1 % of the world's beef, 2 % of the world's mutton and 0.2 % of the pork. This makes SA a very small country and a price taker in meats. China produces more than a third of the world's pork and Australia produces twice as much beef than mutton. In terms of net consumption of beef, the USA is the biggest consumer. The USA, South Africa and Egypt are net importers of beef, while the EU and Australia are net exporters of beef (De Jager 1996a and 1996b).

The USA is by far the most untapped market from a SA meat perspective. With South Africa being eligible to export tariff free to the USA under the African Growth and Opportunity Act, vast opportunities for local meat producers exist to be explored. The USA currently imports more than 1.6 million tons of red meat annually. The declining Rand/Dollar exchange rate makes South African meat very competitive in the USA. Economic problems in markets such as Asia and Russia led to lower economic growth in the USA and Europe and are starting to affect the red meat industry. Because Asia is one of the biggest net importers of beef, pork and chicken meat from the USA, as well as mutton and beef from Australia, these countries are looking for new export opportunities - of which South Africa is one (Willemse, 1999a). South Africa is already, next to Asia, Australia's biggest export destination for mutton.

2.6.2 The Southern African Development Community (SADC) trade protocol

The SADC agreement entails that tariffs on red meat will be reduced to zero over five years by SA, i.e. five equal cuts with the first cut on 1 September 2000. Tariffs on certain tariff lines, i.e. those with a tariff lower than or equal to 25 % but higher than or equal to 17 %, will be eliminated over two years in three steps, while those tariff lines with a tariff lower than 17 % will enjoy zero tariffs as of 1 September 2000. Certain pork and mutton cuts fall in this category. Where specific tariffs apply, these will be eliminated in five steps over four years. Sanitary requirements will still be applied. The non-SACU SADC countries in turn have up to 12 years to reduce tariffs to zero, not necessarily in equal cuts.

2.6.3 Subsidised imports

Agriculture remains the most highly subsidised sector in the world economy. With the introduction of the GATT in 1992, the domestic meat industry was for the first time directly exposed to the EU's agricultural support measures (subsidies). According to an investigation commissioned by the DA in 1998, EU agricultural policies at the time had a significant impact on world beef markets. It was claimed that should the EU liberalise its beef market policy (specifically export restitution), beef prices on world markets would have been higher by 7 to 17 %. SA is classified by the EU in Export Zone 9, which carries the highest beef export refunds. Previous attempts to have the country reclassified by the EU to zones with significant beef industries and, therefore, smaller export refunds have been unsuccessful.

One of the major aims of the Uruguay Round was to bring about further liberalisation and expansion of world trade to the benefit of all (but especially developing) countries through the reduction of tariffs and nontariff barriers. Therefore the Uruguay Round committed WTO Members to fundamentally reform trade policies and eliminate distortions in world agricultural trade. However, the Organisation for Economic Co-operation and Development (OECD) (a 29-member strong group that includes the G-7 and the next tier of relatively wealthy nations) recently confirmed that support to farmers in the industrialised countries, calculated at more that US$ 360 billion in 1999, has returned to the high levels existing before the end of the Uruguay Round. Meat producers in the OECD therefore continue to benefit from relatively high levels of support. Producers of beef and sheep meat are supported to a greater extent than those for pork. The OECD expresses all forms of support through a comprehensive indicator of support - called the Producer Support Estimate (PSE). The average PSEs for meat in the EU ranged from 10 to 20 % for pork, approximately 60 % for beef and approximately 54 % for mutton.

2.6.4 Unsubsidised imports

In the past, beef imports came mainly from the EU, where subsidies were paid to their producers. In such cases import tariffs could easily be justified. Indications are that an increased quantity of unsubsidised beef is imported from countries outside the EU. In the case of mutton, it is mainly imported from Australia and New Zealand. It is common knowledge that these countries do not subsidise agricultural products. This led to questions about the competitive position of the local red meat industry. Especially when tariffs are needed to protect the local industry against unsubsidised imports. The importation of pork is also in the process of moving away from the EU to countries that do not pay export subsidies.

SA has not been able to furnish the total domestic demand for meat products, especially mutton and is therefore classified as a net importer of these products. Despite these shortages with regard to meat production, annual slaughterings of lamb and sheep decreased from approximately 8 million in 1992 to approximately 4,9 million in 1999 – a decrease of 41% (Table 2.2). The slaughtering of both cattle (Table 2.3) and pigs (Table 2.4) over the same period decreased by approximately 14%. Chicken meat production is of course the exception with increases from 563.6 million kg in 1992 to 916.6 million kg in 1999 (Table 2.5). For a complete discussion on production (supply) and consumption (demand), refer to sections 2.3 and 2.4.

As outlined in chapter one, this study intends to evaluate the economic implications of allowing importation of live sheep for slaughtering purposes on the domestic meat market. Several approaches and methods have been employed to investigate the economic implication of changing trade policies and tariff regulations in that direction. An overview of the various relevant studies and methods used, is provided in the following sections representing a wide range of applications and diverse methodological constructs. The following methods range from the use of single and multi-market models within the partial equilibrium framework; to Input-Output (I-O), Social Accounting Matrix (SAM) and Computable General Equilibrium (CGE) models within the economy-wide / multi-sector framework. In the case of partial equilibrium analysis models, the literature review focused on meat-related studies only, but in the case of economy-wide models, the literature reviewed included models dealing with other aspects of relevance.

3.1 Partial equilibrium analysis models

In most cases partial equilibrium analysis consists of estimating relevant demand and supply equations and using estimated parameters (often parameters estimated by other studies are borrowed) to conduct analysis. Different regression methods were used in both the single-equation and simultaneous-equation (system) estimation procedures. Examples of single-equation estimation procedures were found in the application of stepwise and Ordinary Least Squares (OLS) regression analysis, while examples of simultaneous-equation estimation procedures were found in the application of Indirect Least Squares (ILS), Two-Stage Least Squares (2SLS), Maximum Likelihood (ML), two-step full-transform (Prais-Winsten) and Seemingly Unrelated Regression (SURE) Procedure. Analyses, typically, consisted of estimating elasticities, but also of modelling sub-sectors of the economy. Within this framework, indicators were used to assess the impact of price interventions or of policies that shift the demand and supply curves on welfare, government budget, rent, efficiency and the balance of payments. Depending on the extent to which sub-sectors of the economy are modelled, partial equilibrium analysis models can be grouped into either non-equilibrium or equilibrium models.

3.1.1 Non Equilibrium models

Non-equilibrium models are the type of analysis that has been used most frequently in the meat industry of the country to address policy-related questions. Analyses ranged from focusing on either demand or supply, but often also focusing on both demand and supply.

3.1.1.1 Demand analysis models

Various international demand analysis models focused on elasticities, where changes in the quantity of the product in response to changes in product price were evaluated, keeping all other variables in the market constant. Caps (1989) estimated retail demand relationships for steak, ground beef, roast beef, chicken, pork chops, ham and pork loin, based on cross-sectional and time-series data of a retail-food firm located in the USA. The double logarithmic functional form for the respective demand relationships was estimated using the SURE procedure. Brester and Wohlgenant (1997) calculated derived demand elasticities for feeder cattle in the USA. They used the OLS regression procedure on annual data from 1962 to 1994. Chantylew and Belete (1997) analysed the price-quantity and income-quantity relations for beef, mutton/goat, pork and chicken at retail level for Kenya by applying the OLS regression procedure in estimating the equations.

Locally, Du Toit (1982) conducted an econometric analysis of demand for red meat (mainly beef and mutton), concentrating on applying different functional forms using the stepwise regression procedure and calculating elasticities. Hancock (1983) estimated SA's demand for red meat, pork and poultry using OLS, ILS and the 2SLS regression procedures in order to calculate own and cross-elasticities. Hancock *et al.* (1994) also calculated long-term demand elasticities for beef, mutton, pork and poultry using yearly data. Bowmaker and Nieuwoudt (1990) estimated a set of demand equations for 18 SA agricultural products, representing three demand systems (red meats, fruit, and vegetables), from monthly data for the period December 1982 to February 1988. The 2SLS regression procedure was used to obtain the results. The purpose of the study was to promote understanding of how these demand systems function. Poonyth *et al.* (2001a) analysed and measured changes in South African consumers' preferences for meat and consequent meat demand adjustments. SURE, and ML regression procedures were used to estimate red and white meat demand equations. Using the Kalman filtering technique to facilitate the estimation of preference changes from one period to another extended the ML regression procedure. Poonyth *et al.* (2001b), further investigated the dynamics of beef consumption by estimating a static, as well as a dynamic demand for beef and by computing the long-term price and income elasticities. The OLS regression procedure was used to estimate the static demand, while the ML regression procedure was used to estimate the dynamic demand. All the data used were annual.

Simultaneous equation estimation procedures improved the measures of economic efficiency and policy distortions by allowing for inter-market linkages, a feature so important that various specifications with regard to demand system analysis models developed from it. Examples of the following demand systems were found in the literature: the Almost Ideal Demand Systems (AIDS) model, Relative-Price Real-Income (RPRI) model, Linear Approximate AIDS (LA/AIDS) model, Inverse AIDS (IAIDS) model, switching AIDS model, Linear Expenditure System AIDS (LES-AIDS) model, Generalised LES (GLES) model and the Rotterdam model.

The AIDS model was used by Hayes *et al.* (1991) generating a systems' estimate of the South Korean meat sector. The parameters of the demand system were used to simulate the effects of trade liberalisation on the South Korean beef sector. Mdafri and Brorsen (1993) also used the AIDS model to estimate demand elasticities for beef, mutton, poultry, and fish in Morocco, while Gracia and Albisu (1998) used it to estimate a demand system for meat and fish in Spain fitting cross-section data. Gracia and Albusi's aim was to explain different consumption patterns in rural and urban areas, focusing on fresh pork and fish in Spain.

The AIDS model was compared to the RPRI model by Heien, *et al.* (1996). He performed meat (beef, pork and chicken) demand analysis for China, using both the linear RPRI and the AIDS models. Estimation procedures included OLS and SURE regression with corrections for autocorrelation. Results proved that very little difference was found between the AIDS and the RPRI models. Blanciforti and Green (1983) compared the AIDS model to the LES model on annual USA time series data for 1948 to 1978. Demand systems were estimated for four food groups, the commodities were the following: meats (beef and veal, pork, fish and poultry), fruit and vegetables, cereals and bakery products, and miscellaneous foods (dairy products, eggs, imported sugar, and some minor items). They found that the AIDS model proved to fit data for analysing the demand for food commodities better than the LES model.

Several of the specifications are modifications based on the AIDS model. Cashin (1991) and Wahl, *et al.* (1991) employed a demand systems approach, which used the LA/AIDS model. Cashin's study focused on the estimation of the Australian demand for meat between 1967 and 1990. ML regression procedures were used for estimations. Wahl's study focused on the Japanese livestock markets. Eales and Unnevehr (1993) developed an inverse of the AIDS model, the IAIDS model. The purpose thereof was to test the endogeneity of prices and quantities in the USA meat demand system. Using annual data, both prices and quantities appeared to be endogenous. Mangen and Burrel (1999) investigated the changing preferences of Dutch consumers for meat and fish using a switching AIDS. The switching AIDS approach includes time trends to capture underlying trends in unmodelled variables, as well as dummies to capture seasonal fluctuations within the year.

Under circumstances where the functions to be estimated in a demand system are numerous – for example, commodities or products in household expenditure surveys – a two-stage budgeting and price aggregation procedure is used to develop a two-stage demand system that is consistent with constrained utility maximisation. To accomplish this second-stage partial system can be estimated, or the two stages can be modelled separately. Gao *et al.* (1996) employed a second-stage partial system by incorporating upper and lower-level demand models into one estimable system. An extension of the AIDS was used at the upper level and a GLES was used at the lower level. The purpose of his study was to evaluate economic and demographic effects on China's rural household demand for nine food commodities (for instance pork, beef, lamb and poultry) and five nonfood commodity groups. Fan *et al.* (1995) estimated a complete demand system of Chinese rural households using a two stage LES-AIDS model, estimating the two stages separately. Special emphasis was on food commodity groups (meat, amongst others).

The Rotterdam Model is a leading example of a system of demand equations. According to Barten (1964) and Theil (1965) the name "Rotterdam" comes from the location of Barten and Theil in the 1960s. Barten (1964) attempted to fill the gap between the theory of consumer demand and empirical demand research. Specification was based on consumers' expenditure, because the utility function was considered too restricted for the level of aggregation of the data available in his case. A set of time-series data describing total consumer expenditure in the Netherlands on fourteen types of commodities (one of which is meat and meat products) or services and the corresponding price indices covering the periods 1921 to 1939 and 1948 to 1958, was used. Because the regression specification for a certain type of quantity bought contains a number of elasticities, which appear also in the specifications for the other commodities, these coefficients had to be estimated simultaneously. The procedure of SURE regression was used. Internationally, the model has been applied to meat products with the aim to compare the results to the results from LA/AIDS model (Alston and Chalfant, 1993), to test and maintain separability (Moschini, *et al.* 1994), to understand the potential demand in potentially profitable markets (Caps *et al.*, 1994), to project consumption and imports under the assumption of trade liberalisation (Byrne *et al.*, 1995), to isolate the impact of increased beef advertising on quasi-rents at the farm gate by combining its estimates with a Muth-type equilibrium-displacement model (Kinnucan, *et al.* 1996), and to determine the effects of heath information and generic advertising on consumption (Kinnucan *et al.*, 1997).

In SA, a nonadditive dynamically varying version of the Stone-Geary utility function was proposed by Uys (1986) to derive dynamic demand functions for meat (beef, mutton, pork and chicken) by maximising this utility function subject to an expenditure constraint – an Expenditure Model, which is in fact the LES model. Habit formation by the consumer was taken into account and therefore consumption data were broken down according to population group.

3.1.1.2 Supply analysis models

Compared to demand analysis models, only a few examples of supply analysis models could be found in the literature. Von Bach (1990) estimated the supply response of beef in Namibia at a regional, as well as at a national level. The purpose of his study was to determine the SA beef industry's influence on Namibian livestock and beef supplies. Von Bach and Van Zyl (1990) extended this analysis to study the impact of different variables on supply in an attempt to promote the Namibian beef industry. It was found that producer prices did not play a major role in cattle supply. Rainfall and cattle numbers were the most important variables in determining supply. The stepwise regression procedure was used in both cases.

Based on the SA economy, Heydenrych (1975) investigated the relation between beef production (*supply*) and auction prices in the controlled areas at that stage. Du Toit (1982) conducted an econometric analysis of supply for red meat (mainly beef and mutton), concentrating on applying different functional forms and calculating elasticities. The stepwise regression procedure was used to estimate the equations. Laubscher (1982) specified and estimated the total SA supply of beef, with the objective to determine which variables are causing fluctuations in the supply of beef, using the OLS regression procedure. In his attempt to determine whether significant increases in production, efficiency and profitability were accomplished and, if those trends (or lack thereof) are evident, the extent to which they are caused by controlled marketing and accompanying regulations, Lubbe (1992) estimated supply equations for SA beef, mutton and pork. Once again the OLS regression procedure were used.

Availability of data for supply analysis has proved to be a problem in many cases. To estimate a profit function and to derive the gross output supply from it is an alternative used in a number of meat supply analyses. Lopez (1984), Bouchet *et al.* (1989), Fisher and Wall (1990), and Fulginiti and Perrin (1990), accordingly, derived (amongst others) meat supply equations from estimated profit functions for, respectively, Canada, France, Australia and Argentina.

3.1.2 Equilibrium models

3.1.2.1 Single-market models

Market equilibrium models impose market clearance, where demand is equal to supply and prices are determined endogenously. The impact of a price intervention or of policies that shift the supply and demand curves can be analysed in commodity and factor markets.

Alexeev (1987) attempted to overcome the problem of estimating consumer-behaviour models in centrally planned economies, where nonmarket-clearing prices are fixed by the state, by utilising prices in a parallel ‘free’ market. An equilibrium model, incorporating parallel markets, was developed in the United Socialists Soviet Republic (USSR). Demand curves for meat and milk needed to be estimated and was based on OLS and two-step full-transform (Prais-Winsten) regression procedures.

The only meat-related study of this kind done in SA was by Adam (1998). He used the total demand elasticity for beef calculated from a Rotterdam meat (beef, mutton, pork and chicken meat) demand system estimated in the same study, combined it with the price elasticity of supply for beef [calculated by Lubbe (1992)] to construct a general demand-supply equilibrium model for beef. Through this model, the study was then able to extend the results found by Adam and Darroch (1997) – from the effects an FTA will have on consumers to include the effects it will have on producers.

Single-market models do not address the interaction among markets (that is, the substitution effects in consumption and production), and do not devote sufficient attention to income distribution beyond classifying agents (consumers and producers). These models also ignore the impact on and feedback from the rural labour market for example. In addition, agricultural price reforms often include simultaneous changes in several prices, where interaction among the different commodities is critical, and where the effects of policies may not be cumulative across commodities. However, single-market models provide an acceptable first order approximation of total effects (Braverman *et al.*, 1987).

3.1.2.2 Multi-market models

Multi-market models typically consist of analysis based on larger numbers of equations (representing many markets). These demand and supply equations for product and factor markets are, typically, estimated from time-series data. A limited version of the multi-market model, the sector model, was also found in the literature. Sector models differ from multi-market models in that they consist of equations from one sector only. No distinction between sector and multi-market models was made during revision of the literature, because the difference is very technical and authors were often found to have placed their models in the wrong category.

Although not a single application of multi-market models was found in meat-related literature based on the SA economy, a number of applications were found in international literature. Ray and Heady (1972) modeled six US subsectors for livestock together with feed grains, wheat, soyabeans, cotton and tobacco. Policy questions addressed were the roles of government price support, acreage allotment, and technological change on production, prices, trade and farm incomes. Ortner (1988) developed a multi-market model for the cattle and beef sectors, consisting of (1) supply, (2) demand, (3) intermediate consumption of feed, seed and waste, (4) net export, (5) net export revenue, (6) net export subsidy, to estimate the long-term supply elasticities of agricultural products from Austria. The response of farmers to policy decisions was assessed across the agricultural sector and the results of an analysis of farmers' response to the loss of export subsidies in the cattle and beef sector were presented. Wahl, *et al.* (1991) constructed a Japanese livestock (cattle and beef, dairy cattle and import-quality beef, hogs and pork, chicken meat, and fish) multi-market model by combining a meat expenditure system with supply dynamics. The meat expenditure system used in the model complied with the LA/AIDS specification. The purpose of estimating this model was to use it in simulation analysis to consider the probable consequences of alternative Japanese beef import policies on the Japanese livestock industry and beef imports. Brester and Wohlgenant (1997) developed a linear elasticity model of the US beef industry, using log differential equations. The model predicted that the General Agreement on Tariffs and Trade (GATT)/ Uruguay Round would cause asymmetric effects on ground and table cut beef consumers. Twelve equations were specified from the relevant product and factor markets, for 11 of which, the parameters were borrowed from the literature and only one was estimated. The system of equations was solved numerically for relative changes in quantities, input prices and output prices as functions of relative exogenous changes (i.e. those caused by trade liberalisation policies) in imports and exports.

In terms of addressing policy questions, multi-market models proved to be more reliable than single-market models, because they covered a larger field and allowed for more interrelationships between different variables. An important feature of multi-market models is the fact that they are nonlinear. Nonlinearity implies a flexible structure, allowing for complementary as well as substitution effects between consumption and production. These effects in multi-market models are one of their major advantages over economy-wide models, which are usually based on fixed coefficients. Another important feature of multi-market models is the fact that they allow for market clearing in a number of markets. Market clearing implies endogeneity of prices, meaning that prices are determined within the model itself. Through market clearing and endogeneity in prices, multi-market models are extremely useful in determining the impact of policy interventions. Lastly, multi-market models have the advantage of stressing the role of lagged variables, giving them the possibility for serving as forecasting instruments.

3.2 Economy-wide / multi-sector models

Economy-wide models capture the economy-wide effects of specific as well as macroeconomic policies. These models begin with I-O models that are extended to SAM models and then extended to CGE models.

3.2.1 Input-output models

Ever since Leontief (1936) developed an I-O model for the US economy, these models have been the standard means by which inter-industry interactions have been described and studied. I-O models have found many areas of application in economic structure and development studies, in particular through the calculation of various multiplier effects of demand.

Holland and Martin (1993) analysed output changes in the US agricultural economy from 1972 to 1977 using a 477-sector I-O framework. Output changes were broken down into components attributable to technical change, domestic final demand change, export demand change and import substitution. Papayiannis and Markou (1998) revised I-O data for the main crops and livestock enterprises of Cyprus so that it can be used for a variety of purposes, such as, farm planning, budgeting and drawing up, evaluating and implementing agricultural projects and plans. Olsen *et al.* (1998) estimated the economic effects of flooding in the US over a region of interacting floodplains and other lands by incorporating a Leontief economic I-O model with a probabilistic description of the potential overtopping in a system of levees. Papadas and Dahl (1999) raised and discussed issues relating to the derivation, behaviour and characteristics of I-O multipliers where the exogenous changes are not assumed in elements of final demand but in total outputs of sectors and commodities. They also estimated such “supply-driven” multipliers for 16 farm commodities of US agriculture, livestock being one. Frechtling and Horvath (1999) employed a regional I-O model to estimate the multiplier effects of visitor expenditures in Washington, DC. Normal and ratio multipliers were analysed for 37 industry sectors. Buetre and Ahmadi-Esfahani (2000) updated the I-O table for the Philippines from 1985 to 1992 by simulation techniques.

Conningarth Consultants (1999) applied the 1996 I-O table for the SA scenario to calculate various sectoral (gross domestic product, labour and capital) multipliers. They extended their analysis to calculate labour multipliers for 17 industries (amongst others, the livestock industry within the agricultural sector).

Conningarth Consultants (2001) reported that although I-O models can provide a useful approximation of economy-wide impact, they have a number of shortcomings, namely, that resource requirements are considerable and that model results do not reflect economic efficiency, typically do not address changes in technology and are limited by historical data. In addition, Roukens de Lange and Van Seventer (1990) felt that I-O models have been orientated mainly towards the industrial aspect of the economy and have largely ignored the interactions existing between other aspects of the economy. A standard I-O model does not allow for households with different income levels or for population groups with different expenditure patterns. Existing I-O models also do not address other important areas of economic balance and interactions such as those between government expenditure and taxation, savings and investment, and imports and exports. I-O models also ignored the impact on the performance of the economy of issues such as human development and values, as well as political and social conditions.

3.2.2 Social accounting matrix models

To redress some of the bias inherent in the concept of I-O models, it was extended to include other aspects of the social economy in a much larger matrix structure, called SAM models. SAM models consist of series of accounts organised in matrix form, in which national or regional income and expenditures over a given time period must balance. This closed system of social accounts is the consistency check offered by Walras' Law. The literature review proved SAM-based models to provide more realistic estimates of "ripple effects" (i.e. multipliers that define relationships between sectors and national accounts) revealing much about the structure of the economy and focusing on important indirect as well as direct causal linkages.

Hayden and Round (1982) developed an SAM model for Swaziland. One of the model's interesting features was that it distinguished between commodities (products) and production activities (industries). Such a distinction allows more freedom in defining activities according to criteria other than only the characteristic products. The model also allowed for a production activity delivering secondary products and, lastly, it identified rural and urban households. The latter distinction was important in the application of the SAM model, which was used to evaluate a project proposal for building a large thermal power station aimed at converting the available coal resources into a commodity that could profitably be exported to SA. Hayden and Round (1982) also developed a SAM model for Botswana in which they identified rural and urban households. Additionally, in this model it was attempted to integrate a detailed flow of funds into the framework. The Botswana SAM model has been applied to the analysis of the impact of increase in government wages and salaries, the impact of a foot-and-mouth epidemic on the economy of Botswana and the impact of beef price policies on poorer households. Paukert *et al.* (1981), Behrens (1984) and Bulmar-Thomas and Zamani (1989) concentrated on the impact of income redistribution from high to low income groups in their applications of SAM models for, respectively, a number of developing economies, Brazil and Iran. When differences in living standards and income among various groups of households are significantly influenced by regional elements, it is important to include a regional dimension in the SAM model. Pyatt and Round (1985b) and Bell *et al.* (1982), have done exactly that in their applications of SAM models for Malaysia. The latter applied the SAM model in order to undertake a social cost-benefit analysis for the evaluation of an irrigation project. McNicoll and Davies (1987) also included a regional dimension to their SAM model for Pakistan. The SAM model by Pyatt and Round (1985a) for Sri Lanka introduced multiplier decomposition analysis to SAM-model-based policy analysis. It provided an opportunity to investigate the structural interrelationships among various endogenous accounts in the economy. Similar exercises were undertaken by Cohen (1986) for a number of developing economies and by Pyatt (1988) for Malaysia.

In 1986 the first SA SAM (drawn up for 1978) was published by the Central Economic Advisory Service. De Lange and Van Seventer (1990) reviewed subsequent publications in which this SAM was used (Dreyer and Brand, 1986; Van Seventer, 1987; Eckert and Mullins, 1989). The 1978 SA SAM proved to be very useful as a source of consistent data, particularly relating to income and expenditure patterns and distribution. Multiplier analysis was found to have obtained insights into the relative impact of the various population and income groups on economic structure and performance. McGrath (1987) reported that the SA Central Economic Advisory Service had published a report containing SAMs for the entire economy, and for eight planning regions. The aim of McGrath's (1987) study was to critically evaluate the SAM that was based on the 1978 I-O table and the 1980 expenditure patterns. McGrath (1987) found that the wage levels, the strength of black unions, and the exchange rate of the Rand have already changed significantly which places the suitability of the SAM for modelling policy changes under some doubt. Eckert, *et al.* (1992) improved on the SA SAM of 1978 by adjusting the base year to 1988 and by incorporating structural changes that occurred during the 1980s for example: interactions among production activities, total household incomes, household expenditures on commodities and the generation of earned income.

Two major limitations of SAM models are, firstly, that required data are often unavailable. Secondly, production functions implicit in the formulation of a SAM subject the model to assumptions of linearity and homogeneity, providing a quantitative "snapshot" of the economy and do not provide a dynamic formulation of the forces shaping the socio-economic structure of the nation. Both of these limitations can also be applied to input-output models. According to Robinson and Holst (1989), even SAM models are too simplistic for policy analysis. They are demand driven and do not take into account the issues of price adjustments, resource allocation, productivity and factor utilisation. With their fixed coefficients, SAM models further neglect to bring into consideration substitution possibilities in consumption, production, imports and exports and do not capture supply-demand interactions of agents operating across markets in response to shifts in market signals.

3.2.3 Computable General Equilibrium models

Developments to improve on the limitations of SAM models have resulted in so-called CGE models. According to Robinson and Holst (1989) CGE models are nonlinear and operate by simulating the behaviour of agents across markets. In terms of the definition used by Thorbecke, these models are labelled as second-generation SAM-based models and their solution generates relative prices as well as production, employment, and income levels. In essence a CGE model starts from the institutional description of the economy provided by the SAM and involves the supply side and market mechanisms in reconciling supply and demand.

A review of internationally applied CGE models came up with the following. Hertel (1992) developed and compared general equilibrium multi-region, partial equilibrium multi-region, general equilibrium single-region and partial-equilibrium single-region models for European agricultural trade policy reform experiments. In the case of reforms affecting food and nonfood sectors, the partial-equilibrium models performed very well. In this case, the major benefit of general equilibrium analysis was its ability to draw the link between agricultural and non-agricultural interests in trade policy. A neoclassical approach to studying macroeconomic linkages to agriculture has been used by Adelman and Robinson (1978), Taylor (1979), Dervis, *et al.* (1982) and by De Janvry and Sadoulet (1987) in Walrasian CGE models. While the main focus of these models is on income distribution, growth, and structural change, macro-agricultural linkages are basic components of its detailed disaggregated supply structures. Feedback from the macro-economy to agriculture, however, is not intensively investigated. Although some attempts have been made to incorporate Keynesian features and loanable funds markets, the model is generally inadequate in modelling the nominal sectors of the economy, disequilibria situations, dynamics and expectations. Money supply has remained exogenous to the system. Sadoulet and De Janvry (1987) looked into two different types of analysis that impacted on developing countries (India, Peru, Mexico, Egypt, Korea and Sri Lanka) as a result of trade liberalisation. The first is primarily concerned with predictions about world price changes and, for this, uses world models. The second type of analysis takes a single-country approach. They then followed the single-country approach and integrated the multi-market and CGE models, thereby combining the comparative advantages of both approaches: a better specification of the nature of agricultural production compared to previous CGE studies, and a better characterisation of inter-sectoral relations and macroeconomic linkages compared to multi-market models. Hassan and Hallam (1996) developed a CGE model of the Sudan economy with the specific intent to analyse macro-agricultural linkages and evaluate the impact of structural adjustment policies on agricultural supply. An endogenous money creation mechanism was modelled to allow for feedback effects from macro-sectors to agriculture. The Hassan and Hallam (1996) model accommodated micro-structural features in the foreign exchange and domestic credit markets, as well as macro-aggregates through general price levels transmitted to real price movements. Partial adjustment and expectations schemes were used to model supply in the model. Model parameters were estimated econometrically. Dynamic simulation was used to solve the model for validation and policy analysis. Parikh, *et al.* (1997) examined the quantitative impact of trade liberalisation for India with an applied general equilibrium model with nine agricultural sectors, one non-tradable non-agricultural sector and one tradable non-agricultural sector and with five rural and five urban expenditure classes. Different scenarios were generated using the model. Because comparison of GDP in two alternative scenarios can be misleading, the policy alternatives were assessed on the basis of their impact on welfare in terms of equivalent incomes of different expenditure classes. A policy was assessed "preferable" only when the distribution of welfare was found to be preferable in a well-defined way, which demonstrated the importance of accounting for large country effects in the rice trade, as well as of estimating welfare optimal tariff / quota for rice exports – which were shown to be just half a million tons of net export of rice. The results also showed that non-agricultural trade liberalisation was even more important for agriculture than even agricultural trade liberalisation, both of which help accelerate growth.

Turning to a review of domestically applied CGE models, Naude and Brixen (1993) have used a multi-sector CGE model to simulate the effects of economic policies, external shocks and structural adjustments in an attempt to obtain an indication of how economic restructuring in SA should proceed. Four experiments were carried out, namely an increase in government consumption, a decrease in import tariffs, an increase in world prices and an increase in export demand. Joubert, *et al.* (1997) conducted a study funded by the Animal Feed Manufacturers' Association (AFMA). They wanted to determine the possible macroeconomic impact of a further reduction in import duties on livestock products. The study used a CGE model for this analysis. The hypothesis tested was that a reduction in meat tariffs would lead to an increased import penetration, and in general should lead to a reduction in prices. This reduction in prices would also benefit consumers (both final and intermediate) and would be to the detriment of domestic producers and in general to their suppliers of intermediate inputs. The model, however, shows clearly that the theoretical benefit of cheaper imports do not result in lower consumer prices – nullifying the potential advantage of cheaper imports. Keeping this in mind, SA mutton is compared to that of China, the EU, Australia and New Zealand. It was found that (1) SA is the only country where mutton prices are higher than that of beef. (2) It has the highest producer and consumer price, compared to the other countries, which gives a clear indication that imports into the country, will be feasible. (3) Production costs are higher in comparison with that of New Zealand and Australia. Production trends have reached an ultimate low and imports are needed to supplement domestic production. However, these imports and related duties should be realistic and should take the economic impact into account. Although the study launched by AFMA addressed the question of what would happen if import duties on livestock products were to be reduced, it did not address explicitly the effect of an additional quantity of meat available on the domestic market due to live imports for slaughtering purposes. The conclusions from AFMA's study, namely that reduced tariffs will lead to lower producer prices but not necessarily to lower consumer prices, are indicative of what the outcome of the present study is going to be. The difference is that this study will attempt to quantify the effect.

Although CGE or second-generation SAM-based models are more realistic than first-generation SAM-based models, their complexity removes them from the intuitive grasp and judgement of the policy maker, while they can lay no claim on ultimate realism. In many instances the development of CGE models are also not feasible due to data requirements and the high costs involved.

All reviewed models have advantages and disadvantages in their applications. The issue is, however, not which is superior, but which is more appropriate within the given context. Accordingly, the literature review indicated that internationally as well as domestically, policy analysis addressing meat related issues, mainly occurred through partial equilibrium analysis models. Given the specific policy focus of this study, the time available and data limitations, a multi-market approach has been chosen to conduct the intended analysis. The intended multi-market analysis will take advantage of and build on a recent meat demand system analysis study in SA by Adam (1998). Adam's meat demand system will be complemented and extended to model the meat supply and factor market segments of the meat sector and impose equilibrium conditions. A multi-market model for SA meat (mutton, beef, pork and chicken meat) and land (utilised in sheep producing areas) will be developed. The next chapter discusses the theoretical foundations and review various approaches to the application and use of multi-market models.

In this chapter the multi-market model structure and specification to be employed are described in detail. Section 4.1 describes the different approaches to the specification of demand and supply functions necessary for construction of multi-market models. The empirical multi-market model employed by this study is developed in section 4.2. In section 4.3 data needed are discussed and in section 4.4 the econometric procedures used for estimation of the specified functions are explained.

4.1 The multi-market approach

Partial equilibrium models aim to analyse the impact of price and non-price policy shifts on commodity or factor markets. The rest of this section describes the various approaches to estimation of demand and supply on both the product and factor sides of the market, as well as market clearing conditions.

4.1.1 Approaches to demand analysis

Approaches to estimating demand are based on the theory of a fixed amount of consumer's income that is allocated to the purchase of consumers' "goods" in order to maximise utility (Colman, 1983). Two approaches are commonly used. The first is theory-based and the second is more pragmatic.

4.1.1.1 Theory-based approaches to the estimation of demand functions

According to the theory of the consumer, the demand for "goods" is derived from the first order condition (FOC) equations of the utility maximisation (cost minimisation) problem (Deaton and Muellbauer, 1980). Duality in terms of the consumer theory is concerned with using the utility function as an alternative to the expenditure function in representing preferences. Any one of these two functions could be used to derive demand equations, which are then econometrically estimated.

Under utility maximisation, consumers attempt to maximise utility (u) from consumption of a bundle of goods (q), subject to a given level of income (x):

Equation 4-1

Max $u = v(q)$ subject to $p.q = x$

where $p.q = x$ is the budget constraint, *q* is the quantity of "goods" demanded, *p* is the given fixed price paid for "goods" and *x* is total expenditure. The FOC of the maximisation problem are used to solve for Marshallian demand functions $q = g(x, p)$. Through substitution, the indirect utility function is solved for $u = \varphi(x, p)$. Deaton and Muellbauer (1980) discusses six properties as restrictions on the utility function. They are: reflexivity, completeness, transitivity, continuity, non-satiation and convexity. For a detailed discussion of the derivation and properties imposed by theory restrictions on Marshallian demand functions refer to appendix A.

Under the cost minimisation approach the consumers' decision problem is specified for minimising the level of expenditure (*x*) on consumption of "goods" to attain a certain level of utility (Debertin, 1986; Theil, 1980; Sadoulet and de Janvry, 1995; Deaton and Muellbauer, 1980; Chambers, 1988):

Equation 4-2

Min $x = p.q$ subject to $v(q) = u$

where $v(q) = u$ is the given utility function (*p*, *q* and *u* as defined above). The FOC of this expenditure minimisation problem is used to solve for Hicksian demand functions $q = h(u, p)$ using Shephard's Lemma (Deaton and Muellbauer, 1980). The expenditure function is then solved for as $x = c(u, p)$. Theory imposed five regulatory properties on the expenditure function: homogeneity of degree one in prices; increasing utility, non-decreasing in own price, and increasing in at least one other price; concavity and continuity in prices. For a detailed discussion on the derivation and properties imposed by theory restrictions on Hicksian demand functions refer to appendix A.

4.1.1.1.1 Estimation of Engel curves (expenditure functions)

Adding-up problems associated with the estimation of Marshallian and Hicksian demand elasticities have always been understood, but were thought to be unimportant, since virtually all the early studies considered only a fraction of the total budget (Deaton and Muellbauer, 1980; Sadoulet and De Janvry, 1995). Stone’s (1954) famous monograph on *The Measurement of Consumer’s Expenditure* suggests an alternative by distinguishing income (implying the budget constraint) on the one hand and total expenditure on the other.

In situations where only cross-sectional data from household budget surveys are available, which do not contain adequate information on price variations, the Engel curve can be estimated as $q = g(x, z)$. Demand in the Engel curve is expressed as a function of expenditure (*x*) and household characteristics (*z*). An Engel curve however, does not allow price elasticity analysis.

A wide selection of functional forms for Engel curves has been explored in the literature. None of them proved to be fully consistent with adding up (Deaton et al., 1980).

4.1.1.2 The pragmatic approach to the estimation of demand response curves

In this approach to demand analysis, the relationship between demand and a set of explanatory variables chosen on an ad hoc nature on the basis of economic theory and knowledge of consumer’s preferences is directly estimated. The theory of consumption and the consumer, where a fixed amount of consumer’s income is allocated to the purchase of “goods” in such a way as to maximise utility (or to minimise costs) does not fully guide this form of analysis.

Typically the quantity of ‘goods’ demanded (Qd_p) can be determined by: (1) the price of the “good” (*p*); (2) the price of other goods and services (p_o); (3) available income (y_d); (4) fixed financial obligations (*o*); and (5) consumer preferences (*c*) (Du Toit, 1982). The result is a ‘reduced form’ or response curve of the behavioural decision problem:

Equation 4-3

$$Qd_p = f(p, p_o, y_d, o, c).$$

Sadoulet and de Janvry (1995) suggested the use of relative prices (p_i/P) and real income (y/P) instead of *p* and *y*. This will make demand equations homogenous of degree zero in prices and income, ensures that there is no "money illusion" in demand in the sense that it is not affected by a proportional increase in prices and income.

Although the pragmatic approach does not apply and test for theory restrictions it is often used because of a few advantages. First, it operates directly upon the aggregate demand data, which are the object of interest for projection purposes. Second, it is capable of handling dynamic adjustments to demand in ways in which the other procedures cannot. Third, it is the simplest of the procedures in terms of estimation methods and data requirements. Fourth, it entails a smaller number of steps to generate demand response coefficients, which minimises the capacity for specification errors. Fifth, it is a technique, which has shown itself capable of generating acceptable and useful results.

4.1.1.3 Demand system estimation approaches

All of the above approaches to estimating demand can either be applied to single equation or systems of equations. A number of demand systems have been developed and used in the literature. To name a few: the Linear Expenditure System (LES) developed by Stone (1954), the AIDS developed by Deaton and Muelbauer (1980), the Rotterdam model of Theil (1965) and Barten (1964).

Estimation of single demand functions either from time series data following the pragmatic approach or from price variations across clusters in household surveys creates the problem that the quantity projections obtained may not satisfy the requirements of demand theory, particularly the budget constraint. Such predictions are consequently inadequate for the use of complete models such as multi-markets (Sadoulet and de Janvry, 1995). Complete systems of demand equations are able to take into account consistently the mutual interdependence of large numbers of commodities in the choices made by consumers.

4.1.2 Approaches to supply analysis

Approaches to estimating product supply and factor demand are based on the theory of the firm using a fixed bundle of factors that is allocated to the production of products in such a way as to maximise profits or to minimise costs. It will become apparent that each alternative approach and method for empirically estimating supply has its own particular merits. The choice may be influenced by pragmatic considerations such as data availability and time for the study, and upon computing facilities.

Where the intended use of the results is for comparatively short-run forecasting of the supply of some subset of products, directly estimated functions using market level time-series data may well be preferred. This is also true for longer term forecasting of the output of enterprises where there is limited substitutability for other outputs. However, where the objective is sector-wide agricultural policy impact analysis the use of indirectly estimated (cost or profit) functions or the use of directly estimated supply functions through the system approach may be a better option.

For policy analysis purposes it is necessary to impose theory-restrictions upon aggregated market data to extract the required information (Colman, 1983). In the case of directly estimated supply-systems and the theory-based approaches, continuous substitutability of inputs and outputs demands further restrictions through the choice of the functional form of relationships combined with the assumptions of profit maximisation or cost minimisation.

A cost of imposing these restrictions is that the dynamics of supply response are suppressed. The gains, however, are that these methods make allowance in the theoretically consistent way for the technical / economic relationship between all inputs and outputs specified in the models (Colman, 1983).

4.1.2.1 Theory-based approaches to supply analysis

In the theory-based approach, product supply and factor demand functions are obtained from the FOC equations of the profit maximisation (or cost minimisation) problem of the firm. According to the principles of duality, there is a direct equivalence between the production, cost and profit functions. Any one of these three functions could be econometrically estimated and used to derive product supply and factor demand parameters (Fuss and McFadden, 1978; Blackorby *et al.*, 1978; Pope, 1982; Deaton and Muellbauer, 1980). Analysis based on the production function (section 4.1.2.1.1) employs the primal approach, while estimating either the cost or profit function (section 4.1.2.1.2 and 4.1.2.1.3) employs the dual approach.

4.1.2.1.1 The primal approach to estimation of the production technology structure

Production functions *f(x,z)* represent the maximum levels of output producible by combinations of factors (Mansfield, 1968). The primal approach employs this specification to directly estimate the structural properties of production technologies (Debertin, 1986; Chambers, 1988; Fare and Primont, 1995)

Equation 4-4

$$q = f(x, z)$$

The production function (*f*) can be estimated from cross-sectional or time-series data on given output (*q*), input (*x*) and fixed factors (*z*). Properties of the production function are that output is strictly increasing in factors, concavity and continuity, non-negativity of factors, non-empty factors and finite output. Marginal conditions are imposed on the above-mentioned function to derive factor demand equations (Colman, 1983; Chambers, 1988).

The production function, as a method for estimating product supply and factor demand has limitations (Colman, 1983). A very important difficulty to cope with is that of simultaneity bias. Except for the case of using data generated through controlled experiments, levels of inputs and outputs are jointly and simultaneously determined through the decisions of individual firms in response to exogenous economic circumstances. To treat the levels of inputs as exogenous determinants and hence independent of optimal output levels is not wholly appropriate (Marshak and Andrews, 1944; Lau and Yotopoulos, 1972; Colman 1983). Estimating profit and cost functions overcomes this problem. Another advantage of estimating profit and cost functions is the fact that using information from theory restrictions makes it unnecessary to include data on all variables involved in the production process. Arguments that the dual approach is subject to many hypotheses and assumptions, however, are in favour of using the primal approach. Lastly, an important limitation of using the primal approach is the fact that information on levels of inputs and outputs used are often difficult to obtain and observe, especially when farm records are lacking. A lack of information on important data are, however, not unique to this approach.

4.1.2.1.2 The cost function approach to supply analysis

The cost function (*c*) represents a firm's economic behaviour as a cost minimising agent, subject to a given level of output (*y*), under exogenously determined levels of factor prices (*w*) (Chambers, 1988):

Equation 4-5

$$c(w,y)=\min\{w,x\} \quad \text{subject to} \quad L = w.x+\lambda[f(x)-y]$$

where $L = w.x+\lambda[f(x)-y]$ is the Lagrangian expression for the constrained cost minimisation under the technology $y = f(x)$. FOC of this cost minimisation are used to derive factor demand, *x*(*w,y*) and product supply α(w,y). One can then solve for the cost function. Just like the production function the cost function is also restricted to have certain properties, namely: non-negativity, non-decreasing in factor prices, concavity and continuity in factor prices, positive linear homogeneity, non-decreasing in output and no fixed costs (Chambers, 1988).

4.1.2.1.3 The profit function approach to supply analysis

The profit function (π) represents the maximum profit firm's can achieve given a particular production technology as a function of factor and product prices (*w* and *p*, respectively). The firm's decision problem is that of choosing levels of output supply and factor demand that will maximise the firm's profit, subject to the technological constraints:

Equation 4-6

$$\pi(p,w)=\max(p.q-w.x) \quad \text{subject to} \quad h(q,x,z)=0$$

where $h(q,x,z)=0$ is the production possibility set, implying that $q = f(x,z)$ and that *h* is the technology function with output quantities (*q*), variable factors (*x*) and fixed factors (*z*). The FOC are used to derive factor demand *x(p,w,z)* and product supply *y(p,w,z)*. Through substitution the profit function is solved for as $\pi = p.q(p,w,z)-w.x(p,w,z)$. Just like the production and cost functions, the profit function is also restricted to have certain properties, namely: non-negativity, non-decreasing in output prices, non-increasing in factor prices, convexity and continuity in output and factor prices and positive linear homogeneity (Chambers, 1988).

4.1.2.2 The pragmatic approach to the estimation of supply response curves

In this approach to product supply analysis, a set of explanatory variables is chosen on an ad hoc basis using economic theory considerations and knowledge of the technical conditions of production. The theory of production and the firm, where a bundle of factors are allocated to the production of products in such a way as to maximise profits (or to minimise costs), are not fully used to guide this form of analysis.

The five major determinants of the quantity supplied of a product (Qs_p) in a particular market are: (1) the price of the product (p); (2) the prices of factors of production (inputs) (w); (3) the prices of other products (p_o); (4) the technological conditions of production (T); and (5) the goals of the farm firms (O) (Dahl *et al.*, 1977). The goals of producers and the technological conditions are reflected in the form of the function. The result is a 'reduced form' or response curve of the behavioural decision problem, namely

Equation 4-7

$$Qs_p = f(p, w, p_o, T, O).$$

Colman (1983) argues that much attention has been devoted to the pragmatic approach of estimating product supply. One of the advantages proved to be that the degree of stability, which can exist in the supply sectors of such models, is not imposed by restrictions but derives from the consistency of the underlying data. On the other hand he felt that insufficient attention was given to price variables, as own price is not an accurate measure of profitability.

According to Watson (1970), the complexities arising from the underlying investment decision, in livestock models, are such that in time-series regression analysis no satisfactory explanation of supply in terms of prices is likely to be possible. In his view, the relationship between any exogenous price and the desired and actual levels of the capital stock are not likely to be constant; the effect of a given price change on livestock numbers may differ between one period and another. The underlying problem is one of correctly identifying the way in which producers form expectations about the relevant explanatory variables and the way in which they respond to maximise their welfare over time. If farmers do respond differently at different times to the same price change it is because this change is not the sole influence on their expectations. This serves to emphasise the fundamental connection between the incorporation of price expectations into supply models, the lagged role of investment decisions upon supply, and the consequent dynamic nature of supply responses to price. There are many studies, which have taken this into consideration (Watson, 1970; Gardner, 1976; Nerlove, 1958; Almon, 1965).

According to Nerlove and Soedjana (1996) the central simplifying assumption to be able to capture price expectations into supply models is the assumption of separation of expectations and optimising behaviour. Although such separation is a powerful simplification both theoretically and empirically, it is known not to be theoretically correct (Nerlove and Bessler, 1997). In a "theoretically correct," but essentially useless formulation, decisions and expectations are not separable; the explanation of behaviour proceeds directly from assumptions about agents' priors and the dynamic constraints of their optimisation problem to the decisions they take now and in the future in response to future events. A need exists for relaxing or modifying this assumption to provide a clearer framework of analysis for understanding the relation between how expectations are formed and reported and uses to which such expectations are put and the rewards of optimising behaviour (Nerlove and Bessler, 1997).

It is clear from the foregoing discussions that there exist major problems with the pragmatic approach to supply response analysis. It however, remains the most used and preferred method. The most significant factors in its favour, according to Colman (1983) is the same as for the pragmatic approach to demand response analysis as mentioned in section 4.1.1.2.

4.1.2.3 Systems approaches to supply analysis

Development in the dual profit and cost system approaches to indirectly estimate supply response functions, as well as in using the neoclassical theory of the firm to generate restricted systems of directly estimable supply functions, is an ongoing process.

There is no doubt that dynamic analysis of livestock product supply responses is exceptionally complex. The reasons for this are that for cattle, sheep and pigs, a given animal at a given time may be viewed as (a) a finished good, (b) a good in process, or (c) a piece of fixed capital (Hildreth and Jerrett, 1955). This implies the need for simultaneous equation systems to explain output and inventories since it is evident that current prices will affect the number of animals supplied for slaughter and hence all other aspects of livestock supply. However, in the absence of policy measures to fix prices, prices themselves will be affected by current supplies, and hence there will be an interdependency between supplies and current prices.

Other seminal work of systems approaches to supply analysis (production functions) were done by Zellner *et al.* (1966) in the form of a Cobb-Douglas function, De Janvry (1972) in the form of a generalised power function, Brent and Christensen (1973) in the form of a translog function and Christensen *et al.* (1973) in the form of a trascendental function.

4.1.3 Market equilibrium and clearing conditions

For the purpose of this study market equilibrium need to be imposed under the assumption of perfect competition to clear both the product and factor markets. Many of the SA agricultural markets conform quite closely with the perfectly competitive model. A perfectly competitive market exists when no buyer or seller can influence price, output is homogeneous, resources are mobile, and knowledge is perfect (Ritson, 1978; Tomek & Robinson, 1983; Mansfield, 1991). Such a market cannot remain in surplus or shortage under perfect competition, the price moves so as to equate quantity demanded and quantity supplied. This, of course, does not occur in the real world and this model is only a theoretical case at the one end of the continuum of competition in terms of the number of firms.

Under perfect competition product and factor markets will not realise economic profits for a long time. If the market price is below or above P_e (equilibrium price) the quantities demanded or supplied will adjust in the long run to render Q_e (equilibrium quantity). In the short-run, however, individual firms adjust their production decisions to capture short-term profits. In the long-run all firms will produce the optimum and the adjustment process will take the form of entry and exit of sellers from the market.

Just as farm products are channeled from farmers to consumers via agricultural product markets, so productive resources are allocated to farms via factor markets, in which input prices are determined by the interaction of supply and demand for the factor. A profit maximising firm must equate the marginal value product of an input with the marginal factor cost.

In general the multi-market model can, therefore, be presented as follows:

Product market:	Product supply:	$Qs_p = f(p_p, p_f, z_{ps})$	**Equation 4-8**
	Product demand:	$Qd_p = f(y, p_p, z_{pd})$	**Equation 4-9**
Factor market:	Factor supply:	$Qs_f = f(p_p, p_f, z_{fs})$	**Equation 4-10**
	Factor demand:	$Qd_f = f(p_p, p_f, z_{ps})$	**Equation 4-11**
Equilibrium conditions:	Product markets:	$Qs_p = Qd_p$	**Equation 4-12**
	Factor markets:	$Qs_f = Qd_f$	**Equation 4-13**

where

Qs_p	=	the quantity supplied of products
Qd_f	=	the quantity demanded of factors
Qd_p	=	the quantity demanded of products
Qs_f	=	the quantity supplied of factors
p_p	=	product prices
p_f	=	factor prices
z_{ps}	=	shifters of product supply
z_{fs}	=	shifters of factor supply
y	=	income
z_{pd}	=	shifters of product demand

The multi-market model incorporates four classes of agents: producers, consumers, suppliers of factors, and government. As presented in section 4.1.2.1.3, the profit function for a production system represents a state of technology, the contributions to production of a set of private and public fixed factors that are common to the activities of that system, and profit maximisation behaviour by the agents in that system. The profit function yields a system of product supplies (equation 4.8) and factor demands (equation 4.9). Any of the other approaches to supply analysis, presented in section 4.1.2, can also be used to estimate equation 4.8 and 4.9. On the factor side, households supply factors (equation 4.10) as a function of product and factor prices and a set of household characteristics. Other factors are supplied on factor markets independently of household decisions. Total demand for each product is obtained in equation 4.11. Equilibrium conditions on product (equation 4.12) and factor markets (equation 4.13) determines both equilibrium price and quantity.

4.2 A multi-market model for the meat and land sectors in SA

The empirical model used to conduct the intended analysis is developed and presented in this section. The model builds on earlier results from research carried out by Adam (1998) on estimation of a meat demand system for SA, as well as on earlier results from research carried out by Van Schalkwyk (1995) on estimation of a production function for the sheep-grazing region of SA. The said research work is extended in this study to develop and estimate a system of meat supply equations to complete the multi-market model.

4.2.1 Meat products' markets

Although the mutton market is the market of interest in this analysis, the other three meat markets (beef, pork and chicken meat) are also included to allow for substitution and complementarity effects through price adjustments. Market forces are allowed to determine the quantity of meat slaughtered and the price meats realise.

4.2.1.1 The meat demand system

As mentioned earlier, this study used parameter estimates of a meat demand system (the Rotterdam model) estimated by Adam (1998) for SA. The Rotterdam model is based on differentiated consumption functions, which were derived by maximising the utility function subject to the budget constraint; and formulated in terms of changes in budget shares over time. Separability conditions were imposed on the utility function in order to reformulate consumption for all goods into demand for groups of goods and for individual goods within their respective groups. Applying the Rotterdam model to the consumption for meat in SA, Adam (1998) specified the model as:

Equation 4-14

$$pcbscc_i = f\left(lcvtmc, lcrp_i, lcrp_k\right)$$

where

pcbscc$_i$	=	per capita budget share change in the consumption of meat *i* (*i* = mutton, beef, pork and chicken meat)
lcvtmc	=	log of value changes in total meat consumption in SA
lcrp$_i$	=	log of retail own price changes of meat *i*
lcrp$_k$	=	log of retail price changes of other meats *k*

The estimated coefficients of the parameters of the above meat consumption system model used in the multi-market analysis are presented in Table 4.1:

Table 4-1: Estimated demand system parameters for SA

	Constant	μ_i/M_g	π_{ibeef}	$\pi_{ichicken}$	$\pi_{imutton}$	π_{ipork}
Beef	-0.430	0.667	-0.237	0.070	0.129	0.037
Chicken	0.780	0.076		-0.061	-0.002	-0.008
Mutton	-0.330	0.222			-0.131	0.004
Pork	-0.005	0.041				-0.030

Source: Adam (1998)

4.2.1.2 The meat slaughtering system

This study will estimate slaughtering functions for SA meat (mutton, beef, pork and chicken meat). In section 4.1.2 the different approaches to estimating supply functions were discussed. Both the theory-based and pragmatic approaches have their advantages. The theory-based approach can be used to estimate the meat product supply and to derive factor demand if farm level data are available. Since the required data are not available, the pragmatic approach was adopted in this study. Both single equation and systems of equations estimation methods were applied. Different specifications of the following slaughtering model were estimated:

Equation 4-15

$$sl_i = f\left(ap_i, ap_{om}, p_{ym}, p_w, p_{ss}, p_{bh}, rp_i, rp_k, rp_{om}, ni_i, r_j, vi_{fcp}, pi_{fr}, hn_j, st_j, sp_j\right)$$

where

sl_i = slaughterings for meat *i* (*i* = mutton, beef, pork and chicken meat)
ap_i = auction price of meat *i*
ap_{om} = auction price of other meats
p_{ym} = price of yellow maize
p_w = price of wool
p_{ss} = price of sheep skins
p_{bh} = price of beef hides
rp_i = retail price of meat *i*
rp_{om} = retail price of meats
rp_e = retail price of eggs
ni_i = net imports of meat *i*
r_j = rainfall in animal *j* (*j* = sheep, cattle, pigs and chickens) grazing regions
vi_{fcp} = volume index of field crop production
pi_{fr} = price index of farming requisites
hn_j = heard numbers of animal *j*
st_j = stock of animal *j* lost due to theft
sp_j = stock of animal *j* falling pray to problem animals

i used here denote meats and *j* denotes animals.

4.2.1.3 Meat market equilibrium

In competitive meat markets, prices and quantities must be determined under equilibrium conditions. This requires that all markets clear according to the following market equilibrium condition:

Equation 4-16

$$sl_i + i_i = c_i + e_i + l_i$$

where

sl_i = slaughterings for meat *i* (*i* = mutton, beef, pork and chicken meat)
i_i = imports of meat *i*
c_i = consumption of meat *i*

e_i = exports of meat *i*

l_i = losses of meat *i*

Domestic slaughtering is not equivalent to domestic consumption as meat markets are open to international trade and supply is therefore supplemented by imports while domestic demand is supplemented by exports. The demand side of the equation is, however, balanced with supply by losses that occur in the market. Losses are defined as parts of the carcass that is lost in the butchering and transportation processes and is assumed to be one percent of total production.

Slaughterings for meat *i* (s_i) were estimated according to equation 4.15, while consumption for meat *i* (c_i), was derived from equation 4.14, where consumption is expressed as the per capita budget share change in the consumption of meat *i* ($pcbscc_i$). Adam (1998) developed demand equations which are formulated in terms of changes in budget shares over time, as the Rotterdam Model adapted from Theil (1978) is not attractive when interested in Slutsky symmetry and consumer demand theory is rather viewed as an allocation theory: The consumer is concerned with the dollar amount to be allocated to each good, given the total amount of income available and the prices of all goods.

Rewriting Adam's (1998) formulas, $pcbscc_i$ can be transformed into the per capita consumption for meat *i* (pcc_i), expressed in kilograms:

Equation 4-17

$$pcc_i = \exp\left(\ln pcc_{i,t-1} + \frac{pcbscc_i}{cwabs_i}\right),$$

where

$\ln pcc_{i,t-1}$ = log of per capita consumption of meat *i*, lagged with one year

$cwabs_i$ = conditional weighted average budget share of meat *i*

All that remains is to multiply pcc_i by the population (*pop*) and to divide by a million in order to express the variable in terms of 1000 tons consumed (c_i):

Equation 4-18

$$c_i = \frac{pcc_i * pop}{1000000}.$$

4.2.2 Factor markets

Land, labour, feed, capital and entrepreneurship are the main factors involved in the production of meat products. In the case of beef, pork and chicken meat, mainly produced under intensive production practices, feed is the most important production factor (Venter, 2001). In the case of mutton, mainly produced under extensive production practices, land is the most important production factor (Venter, 2001). Purely based on the limitations of this study in terms of its time frame and budget, it was decided to include only one factor market in the multi-market model and because the mutton industry is the focus of this study, the land market was accordingly chosen.

For the purpose of the land demand equation for mutton producing areas, this study builds on parameter estimates of a production function, representing the value of land in the sheep-grazing region during 1986, estimated by Van Schalkwyk (1995).

Van Schalkwyk's (1995) study mainly focused on the quantification of variables, which influence land price movements in the commercial agricultural sector of SA. Certain macro economic trends have been pointed out, the influence of capital gains and losses on the decisions of farmers and financial institutions was analysed and discussed. The difference between the market value and agricultural value of land was quantified, forces influencing the gap between the market and agricultural value of land were identified and the possible effects of land tax on SA farmland was analysed.

The difference or gap between the market and agricultural value of land, which is normally positive, is caused by non-farm factors such as policy distortions, policy and institutional expectations, decisions by public and private sector lenders and the expectations of land owners and financial institutions that get capitalised in land values. Van Schalkwyk (1995) used different approaches to calculate the difference between the market value and agricultural value of land, of which the marginal value product approach was one. For this approach Van Schalkwyk (1995) had to estimate production functions for the summer grain, winter grain, cattle grazing and sheep grazing regions. The hypothesised production function was:

Equation 4-19

$$y = f(x_1, x_2, ... x_6)$$

where

y	=	total receipts in Rands
x_1	=	number of hectares of farmland
x_2	=	Rand value of all cash expenses except hired labour, rent, taxes, insurance, interest paid, livestock purchases, and feed purchases
x_3	=	Rand cost of feed purchases
x_4	=	average Rand investment in livestock
x_5	=	average Rand investment in machinery and equipment
x_6	=	wages paid to labour

The regression results of the sheep grazing region's production function, as estimated by Van Schalkwyk (1995) are presented in Table 4.2. Van Schalkwyk (1995) fitted several production functions, using dummy variables to distinguish between the four years under observation. The observation year, 1986 (represented by D_1), resulted in the best regression results and was, as in the case of Van Schalkwyk's (1995) study, used for further analysis.

Table 4-2: Estimated production function parameters for the sheep-grazing region of SA

Intercept	X_1	X_2	X_4	D_1
1.002	0.209	0.646	0.164	0.115

Source: Van Schalkwyk (1995) Modeling SA agricultural land prices

By differentiating the production function of the sheep-grazing region for 1986, as estimated by Van Schalkwyk (1995), with respect to the number of hectares farmland (X_1), the demand for land is derived. The derived land demand function is:

Equation 4-20

$$x_l = f(x_2, x_4)$$

where

x_1 = number of farmland hectares

x_2 = Rand value of all cash expenses except hired labour, rent, taxes, insurance, interest paid, livestock purchases, and feed purchases

x_4 = average Rand investment in livestock

The coefficients of the derived demand for land, to be used in the multi-market analysis, are presented in Table 4.3:

Table 4-3: Derived land demand parameters for the sheep-grazing region of SA

Intercept	X_2	X_4	D_1
0.138	0.817	0.207	0.145

For the purpose of the land supply equation for mutton production the quantity of land supplied in sheep producing areas is assumed to be fixed by the total amount of hectares available for field grazing (Mansfield, 1999). The argument is based on the fact that sheep production is geographically situated in areas where land does not have many competitive production alternatives. For the exception of alternatives such as game, ostrich and goats, land will lie barren if not used for sheep production. Land will, therefore, still be available. Accordingly, the total amount of hectares available for field grazing in sheep producing areas constitutes the supply of land in sheep producing areas, which was estimated at 16 627 186 hectares (DAS).

As in the case of competitive meat markets, land markets also need to determine prices and quantities under equilibrium conditions. This requires that the land market clear according to the following market equilibrium condition:

Equation 4-21

$$x_1 = z$$

where land demanded (x_l) (refer to equation 4.28) is equal to a fixed level of land supplied.

4.2.3 Modelling the policy environment and instruments

Quantitative import controls on red meat were abolished in 1993. SA was under pressure by its GATT trading partners to substantially liberalise and eliminate various protectionist measures that were in place, such as formula duties and import controls. In the meat industry, SA translated specific duties and formula duties into *ad valorem* duties. Accordingly, the following tariffs are imposed on the imports of meat products:

Table 4-4: Tariffs taxed on the imports of meat products

Article Description	General Rates of Duty
Meat of Bovine Animals (Fresh, Chilled or Frozen):	
– Carcasses and half-carcasses	40 %
– Other cuts with bone in	40 %
– Boneless	40 %
Meat of Swine (Fresh, Chilled or Frozen):	
– Carcasses and half-carcasses	15 %
– Hams, shoulders and cuts thereof, with bone in	15 %
– Other:	
= Rib	free
= Other	15 %
Meat of Sheep (Fresh, Chilled or Frozen):	
– Carcasses and half-carcasses of lamb	40 %
– Other meat of sheep	
= Carcasses and half-carcasses	40 %
= Other cuts with bone in	40 %
= Boneless	40 %
– Meat of goats	40 %
Edible Offal of Bovine Animals, Swine, Sheep (Fresh, Chilled or Frozen):	
– Of bovine animals (fresh, chilled or frozen)	
= Liver	30 %
= Other	free
= Tongues	free
– Of swine (fresh or chilled)	free
– Of swine (frozen)	
= Livers	30 %
= Other	free
– Other (fresh, chilled or frozen)	free
Meat of Poultry (Fresh, Chilled or Frozen):	
– Of fowls of the species Gallus domesticus:	
= Not cut in pieces (fresh or chilled)	Free
= Not cut in pieces (frozen)	27 %
= Cuts and offal (fresh or chilled)	free
= Cuts and offal (frozen)	
– Boneless (excluding cuts)	free
– Boneless cuts	5 %
– Offal	free
– Other	220 c/kg
Pig Fat, Free of Lean Meat, and Poultry Fat, Not Rendered or Otherwise extracted (Fresh, Chilled, Frozen, Salted, in Brine, Dried or Smoked)	8 c/kg

Article Description	General Rates of Duty
Meat and Edible Meat Offal (Salted, in Brine, Dried or Smoked); Edible Flours and Meals of Meat or Meat Offal:	
– Meat of swine	
= Hams, shoulders and cuts thereof, with bone in	40 %
= Bellies (streaky) and cuts thereof	40 %
= Other	40 %
– Meat of bovine animals	40 %
– Other	40 %

Source: Jacobsens Customs and Excise Tariff Book, 2000

At the time of these negotiations, trade of meat in the form of live animals was unthinkable due to sanitary and animal welfare reasons, and so, the SA tariff book did not make provisions for a distinction between imports of live animals for breeding purposes and imports of live animals for slaughtering. Other countries, such as the USA and the EU, do make a distinction between these two categories. Whereas no tariffs are normally levied on imports of live animals for breeding purposes, different levels of tariffs (Table 4.4) are levied on imports of live animals for slaughter. In SA, one tariff line covering both categories exists, with a GATT bound and applied tariff of zero per cent.

The Marrakesh Agreement provided for reduction of subsidies on agricultural products. However, the agreement did not require the elimination of subsidies and consequently subsidies will continue to distort international trade of, amongst others, red meat. Intervention by way of subsidies on exports, by especially the EU is significant as far as meat of bovine animals and swine is concerned. The Board of Tariffs and Trade is of the opinion that producers in SA, as well as in the other member states of the SACU, cannot compete against the EU's subsidised meat in the SA market without tariff protection (Meat Board, 1994). In order to prevent a detrimental influence on the long-term future of the industry in SACU, protection against such imports was justified. The price disadvantage experienced in the case of mutton and lamb, relative to the products imported from Australia and New Zealand, cannot be attributed to government intervention in those countries. This price disparity is caused by the fact that sheep meat is an offal product to, amongst others, Australia's wool industry.

Therefore imports of meat i are an important exogenous variable that is included in the model. It is argued that the effect of importing live sheep with the intention to slaughter on arrival will have the same economic implications as importing mutton of the equivalent amount. Therefore, imports of mutton (i_m) are also used as a policy instrument, whereby the economic implications of importing live sheep will be analysed. To include its effect on slaughterings, net imports of mutton (ni_m) is included as an explanatory variable in the meat supply system (section 4.2.1.2).

4.3 The data

4.3.1 Data used in estimating the slaughtering system

Table 4.5 summarises the data used in the specification of equation 4.15. Only series for the period 1971 to 2002 were obtained and utilised in the estimation.

Table 4-5: Slaughtering system variables

Variable Name	Description	Unit of measure	Source
sl_i	Slaughterings for meat *i* (*i* = mutton, beef, pork and chicken meat)	1000 tons	DAS
ap_i	Auction price of meat *i*	c/kg	SAMIC and DAS
ap_{om}	Auction price of other meats	c/kg	SAMIC and DAS
p_{ym}	Price of yellow maize	R/ton	DAS
p_w	Price of wool	c/kg	DAS
rp_i	Retail price of meat *i*	c/kg	SAMIC and Adam (1998)
rp_{om}	Retail price of meat	c/kg	SAMIC and Adam (1998)
ni_i	Net imports of meat *i*	1000 tons	DAS
r_j	Rainfall in animal *j* (*j* = sheep, cattle, pork and chickens) grazing region	mm	Weather burro of SA
vi_{fcp}	Volume index of field crop production	1995 = 100	DAS
pi_{fr}	Price index for farming requisites	1995 = 100	DAS
hn_j	Heard numbers of animal *j*	numbers	DAS
p_{ss}	Price of sheep skins	R/piece	Standard Bank
p_{bh}	Price of beef hides	R/piece	Standard Bank
rp_e	Retail price of eggs	c/kg	DA and Stats SA
st_j	Stock theft of animal *j*	numbers	Stock theft Unit
sp_j	Stock of animal *j* falling pray to problem animals	numbers	n/a

<u>Slaughterings</u>

The domestic quantity supplied of meat was based on slaughterings for meat data obtained from the DAS's food balance sheet.

<u>Own and substitute meat prices</u>

Both auction and retail prices are included in the slaughtering system specification (equation 4.15) as producers may either base their slaughtering decision on the price that they receive for the product or on the price that the consumer pays for the product. Meat products are substitutes in that consumers switch between buying different meat products according to their preferences and relative prices, as well as to a lesser extend in that producers switch between producing different meat products as market demand and prices dictate.

Auction prices for mutton, beef and pork were obtained from SAMIC for the period 1960 to 2001 and for chicken meat from DAS for the period 1987 to 2001. Retail prices were obtained from Adam (1998) for the period 1971 to 1996 and from SAMIC for the period 1997 to 2001. It was evident from the data that there is only a marginal difference between producer and consumer prices. Accordingly, the percentage difference in 1987 were used to generate the auction price for chicken meat based on the retail price minus 18 percent for the period 1971 to 1986.

Production costs

Yellow maize makes out a major component of animal feed and hence determines the price of feed, which is one of the most important inputs to the production of meat. Up until 1996 the price of yellow maize was regulated. At the beginning of the season the minister would announce a price that was paid out as an advance to producers and at the end of the season a final payment was made. The gross price being the announced price and the net price being the actual price producers received. As from 1997 the price of yellow maize was deregulated and, hence, the gross price became the same as the actual price producers receive. Therefore the net price of yellow maize as published in the DA's Abstract of Agricultural Statistics (2003) between 1971 and 1996 was used, while the gross price was used between 1997 and 2002. Prices were only available in split years. Accordingly, the marketing year were adjusted upwards to represent calendar years. The price index of farming requisites was used to represents inputs other than feed, needed for the production of meat (DAS, 2003).

Prices of complementary products

Sheepskins are seen as additional sources of income to producers of mutton. Should the price of sheepskins rise drastically, the mutton producers' decision to slaughter will be influenced. The same argument applies to beef hides in the case of beef production.

Sheepskin prices were based on a weighted average of 60 and 40 per cent of Dorper and Merino skins, respectively, for the period 1988 to 1997. Estimates for the rest of the period were based on the difference between prices fetched for Class A meat and contract prices (of live animals), as offal covers the slaughtering costs. Contract prices offered by abattoirs and/or meat traders include the price for sheepskins, while auction prices published by SAMIC excludes the price for sheepskins. The difference, therefore, is a good estimate of sheepskin prices. As in the case of sheepskins, prices for beef hides were also only available for the period 1988 to 1997 and estimates for the rest of the period were also based on the difference between the price fetched for Class A meat and contract prices (of live animals).

Prices of other production alternatives

Wool in the case of mutton production and eggs in the case of chicken meat production are seen as production alternatives. Should the price of wool change drastically, a mutton producer is expected to reconsider his slaughtering decision and the same argument would apply to a drastic change in the price of eggs.

Wool prices could only be obtained in split years from the Abstract of Agricultural Statistics (DAS, 2003) and were adjusted upwards to represent calendar years. Egg prices could only be obtained at retail level and only as from 1973.

Exposure to world markets

It is expected that the degree of an industry's exposure to world markets will influence its production decision. Net meat imports were used as a proxy to measure this effect. Both imports and exports were obtained from the DAS's food balance sheet data.

Quality of grazing

The quality of grazing is expected to influence mutton and beef producers' slaughtering decisions, as major sections of these industries are extensive producers. Mutton and beef producers are inclined to build stock (slaughter less) in years of abundant grazing, while they are forced to slaughter their stock in years of poor grazing. Rainfall in sheep and cattle grazing regions, as well as the volume index for field crop production was used as proxies for quality of grazing.

The sheep-grazing region was defined by the following magisterial districts: Calvinia, Carnarvon, Fraserburg, Kenhardt, Sutherland, Aberdeen, Britstown, Colesberg, Graaf-Reinet, Hanover, Beaufort-West, Victoria-West, Richmond and Murraysburg. This definition of sheep-grazing regions mainly covers the Karoo and doesn't include the Northern Cape, high rainfall sourveld of the eastern Transvaal or the central grassveld of the Free State. The following magisterial districts defined the cattle-grazing regions: Kuruman, Mafikeng, Vryburg, Potgietersrus, Waterberg, Soutpansberg and Thabazimbi. The Soutpansberg magisterial district doesn't have a weather station and accordingly the average rainfall for the adjacent districts Messina, Bochum and Pietersburg were used. These regions were adopted, for the purpose of this study, following Van Schalkwyk's (1995) study in estimating a production function for land in different agro-economic regions.

Herd numbers

Herd numbers will directly influence meat producer's slaughtering decisions. In the case of both sheep and cattle, data for the period 1971 to 1995 excluded non-commercial herd numbers. An adjustment of 13 and 55 percent, respectively, for sheep and cattle were made based on the average percentage difference between herd number including non-commercial farmers and herd numbers excluding non-commercial farmers for the period 1996 to 2001. In the case of pork data were only available as from 1988 and in the case of chicken no data were obtainable.

Stock losses

In a sense stock numbers already cover the effect of stock losses on producer's slaughtering decision. Stock losses due to theft and falling pray to predator animals may have additional effects on producers, for instance, to make them resistant to meat production all together. No data is available on stock falling pray to predator animals, while stock theft numbers could only be obtained for sheep and cattle as from 1988.

4.3.2 Data used to simulate the meat and land multi-market model

In order to be able to determine whether the model performs satisfactorily, historical data were needed on the variables included in Adam's (1998) Rotterdam demand system, on the supply system as estimated in this study, as well as on Van Schalkwyk's (1995) regional production functions. Unfortunately, this study could not access the data used by Van Schalkwyk (1995). Therefore, the model was solved without the factor market, i.e. only including the product market for the period 1976 to 1996).

To reconcile differences between Adam's Rotterdam demand system and the meat supply system estimated by this study it was necessary to calculate the conditional weighted average budget share of meat *i* ($cwabs_i$). In the context that Adam (1998) used 'conditional', it is interpreted as meaning 'within the group'.

Moreover, the log of retail price changes of meat *i* ($lcrp_i$) was transformed into retail prices expressed in cents per kilogram.

The only additional series for which data were needed was population numbers (*pop*) and were supplied by Statistics SA. It was used to transform Adam's (1998) per capita data (Equation 4.18).

4.4 Econometric estimation procedures

As mentioned in sections 4.1.1.3 and 4.1.2.3, approaches to estimating demand and supply can either be based on single equation or on systems of equations. The advantage of using the systems approach is that interdependencies among the equations in the system are taken into account. While this is an important advantage, system approaches do not come without a cost. Miss-specification of one of the equations in the system may "contaminate" estimates for the other equations. Since both approaches have their advantages and disadvantages. This study compared the single equation and systems estimation approaches.

4.4.1 Estimation of single equations

Regression analysis is largely concerned with estimating and/or predicting the (population) mean or average value of the dependent variable (*Y*) on the basis of the known or fixed values of the explanatory variables (*X*) (Gujarati, 1995; Pindyck and Rubinfeld, 1998). The regression model can be expressed as:

Equation 4-22

$$Y_i = \beta_i \sum_{i=1}^{n} X_i + u_i$$

where β_i and u_i are the population parameters and error term, respectively. This specification is known as the Population Regression Function (PRF). In most practical situations only a sample of the population is available and the Sample Regression Function (SRF) is estimated to represent the PRF.

Equation 4-23

$$Y_i = \hat{\beta}_i \sum X_i + \hat{u}_i$$

where $\hat{\beta}_i$ and $\hat{u}_i$ are the sample estimates of the population parameters and error term, respectively. There are several methods for estimating the SRF parameters. The method that is used most extensively is the method of OLS. The method of OLS chooses the SRF parameters that minimises the sum of the squared residuals. As the objective is not only to obtain $\hat{\beta}_i$ but also to draw inferences about the true β_i, it is necessary to make certain assumptions about the manner in which Y_i are generated. The Gaussian, standard, or Classical Linear Regression Model (CLRM), which is the cornerstone of most econometric theory is based on the following assumptions (Johnston, 1984; Gujarati, 1995; Pindyck and Rubinfeld, 1998):

Assumption 1: linear regression model

Assumption 2: *X* values are fixed in repeated sampling

Assumption 3: zero mean value of disturbance u_i

Assumption 4: homoscedasticity or equal variance of u_i, where the conditional variances of u_i are identical

Assumption 5: no autocorrelation between the disturbances

Assumption 6: zero covariance between u_i and X_i

Assumption 7: the number of observations *n* must be greater than the number of parameters to be estimated

Assumption 8: variability in *X* values. The X values in a given sample must not be the same.

Assumption 9: the regression model is correctly specified

Assumption 10: there is low multicollinearity

Given the assumptions of the CLRM, the OLS estimators possess best linear unbiased (BLUE) properties as contained in the well-known Gauss-Markov theorem. As the objective of this study is estimation as well as hypothesis testing, normality of the probability distribution of the disturbances u_i is a required additional assumption ($u_i - NID\left(0, \sigma^2\right)$). The Jarque-Bera test of normality was applied for the purposes of this study.

Empirical work based on time series data, as is the case in this study, requires that the underlying time series are stationary, which means that the mean, variance and autocovariance (at various lags) remain the same no matter at what time they are measured (Gujarari, 1995; Pindyck and Rubinfeld; 1998). Firstly, informal tests were used to determine the presence of unit roots and, accordingly, their order of integration by plotting the data. Secondly, the formal testing strategy suggested by Harris (1995) based on the Augmented Dickey Fuller (ADF) test with a generous lag structure which allows for both constant and trend terms, followed by the sequential testing strategy of the Phillips Peron (PP) test were followed.

The Cobb-Douglas (CD) form was used to measure the relationship between dependant and independent variables (Gujarari, 1995).

Equation 4-24

$$Y_i = \prod_{i=1}^{n} X_i^{\beta_i} e^{u_i}$$

The CD function is one of the most used forms for supply analysis due to a number of advantages over other functional forms. One important property of the CD function is that it is linear in parameters. The CD function parameters can therefore be directly estimated from the linearised double-log.

Equation 4-25

$$\ln Y_i = \beta_i \sum \ln X_i + u_i$$

This form is particularly popular in applied work using OLS regression. The coefficients of the double-log function (equation 4.31) directly measure elasticities and are easier to interpret. The CD form, however, imposes certain restrictions on the structure of the estimated relationship (Gujarari, 1995).

The traditional econometric methodology assumes a particular econometric model and tries to see if it fits a given body of data. In most practical econometric research, once a model is given, estimating its parameters and engaging in hypothesis testing is trivial. The task of determining what the appropriate model is to begin with is very demanding. The latter task is the subject of specimetrics and is applied in this study according to Hendry's approach to model selection. The Hendry or London School of Economics approach to econometric modeling is popularly known as the top-down or general to specific approach in the sense that one starts with a model with several regressors and then whittles it down to a model containing only the 'important' variables (Johnston, 1984; Gujarati, 1995).

For the process of model selection three criteria are commonly used, and also applied in this study to determine how well a model fits the data. First, whether the signs of the estimated coefficients are consistent with the theoretical or prior expectations. Second, whether the estimated coefficients are statistically significant (e.g. $\beta_i \neq 0$). Third, whether the power of the regression model in explaining the variation in the dependent variable is high, as measured by the adjusted coefficient of determination $\overline{R}^2$. As mentioned above the model also has to be tested, at this point, for normality as well as for the other assumptions of the CLRM.

Multicollinearity is the existence of linear correlations among (some or all) explanatory variables of a regression model. Factors contributing to the presence of multicollinearity are data collection methods employed, constraints on the model or in the population being sampled, model specification and an over determined model (Gujarati, 1995; Pindcyk and Rubinfeld, 1998). In the presence of multicollinearity, OLS still generates the best linear unbiased estimators. Large variances and covariances, wider confidence intervals, high R^2 but few significant *t* ratios and sensitivity of OLS estimators and their standard errors to small changes in data; are, however, a problem. As multicollinearity is essentially a sample phenomenon, no unique method of detecting it or measuring its strength exists. A few indicators, of which, auxiliary regressions ($R_i^2 > R^2$), tolerance inflation factors close to 0 and variance inflation factors greater than 10 were used for the purposes of this study. Several remedial measures exist, especially in terms of improving the sample or transforming the data. In case it is impossible to improve on the data, omitting a highly collinear variable may be an option, as long as this does not lead to specification bias.

Heteroscedasticity is the unequal spread or variance of the disturbances u_i appearing in the PRF. Some of the reasons for heteroscedasticity are improved data collecting techniques, the presence of outliers and specification bias (Gujarati, 1995; Pindcyk and Rubinfeld, 1998). Heteroscedasticity is more common in cross-sectional than in time series data and does not destroy the unbiasedness and consistency properties of OLS estimators, but these estimators are no longer minimum variance or efficient. Among others, heteroscedasticity is detected by the White heteroscedasticity test (White, 1980; Gujarati, 1995; Pindcyk and Rubinfeld, 1998), which was used in this study. Several remedial measures exist of which White's heteroscedasticity consistent coefficient covariance is applied in this study. This estimate adjusts OLS variances and standard error so that the valid statistical inferences can be made about the true parameter values.

Auto or serial correlation occurs when the disturbance term related to any observation is influenced by the disturbance terms of any other observation. Serial correlation is more common in time series data, especially if observations are short and exist because of sluggishness, specification bias, the cobweb phenomenon, lags and the manipulation of data (Gujarati, 1995; Pindcyk and Rubinfeld, 1998). As in the case of heteroscedasticity, in the presence of serial correlation the OLS estimators are still linear-unbiased as well as consistent, but they are no longer efficient (minimum variance). Among others, serial correlation is detected by the Durbin-Watson *d* test of first order serial correlation (if *d* is around 2 there is no positive or negative serial correlation) (Johnston, 1984; Gujarati, 1995; Pindcyk and Rubinfeld, 1998) and by the Breusch-Godfrey (BG) test of higer-order serial correlation (Breusch, 1978; Gujarati, 1995). The presence of serial correlation, in this study, was corrected by applying the Cochrane-Orcutt (Gujarati, 1995; Pindcyk and Rubinfeld, 1998) two-step procedure, where the coefficient of serial correlation is determined in the first step and used in the second step to transform the data.

4.4.2 System of equations estimation

The econometric principles discussed above are also applicable to the estimation of systems. As in the case of single equation estimations, various techniques for econometric estimation of systems exist. The SURE, Full Information Maximym Likelihood, Generalised Methods of Moments, 2SLS, Three-stage Least Squares, Weighted Least Squares and OLS are common examples (Johnston, 1984; Pindyck and Rubinfeld, 1998).

The SURE estimation procedure was used in this study. The choice of this method, also known as the multivariate regression or Zellner's method is justified as it accounts for both heteroskedasticity and contemporaneous cross-equation error correlations. In addition, the SURE estimation is appropriate when all the right hand side variables are assumed exogenous, and when some common factors, which are not explicitly modelled, influence the disturbances across equations (Johnson and DiNardo, 1997).

The first section of this chapter (section 5.1) explains discrepancies in the data between different sources. Section 5.2 analyses the univariate characteristics of the slaughtering system data. Results of the empirical estimation of meat slaughtered are given in section 5.3 and compared with the literature in section 5.4. The meat sub-sector model is presented in section 5.5, specifying the additional auction price system, its data needs and univariate characteristics thereof, results of the empirical estimation of auction prices paid to producers, as well as the model's baseline and scenario results. All applications are done by making use of the quantitative micro software, Eviews 4.1.

5.1 Discrepancies in the data between different sources

This study had access to data from two sources. The DAS which is a governmental institution and keeps data on mutton, beef, pork and chicken meat and the SAMIC which is a private sector institution and keeps data on mutton, beef and pork. Comparable data for chicken meat were not available from the private sector and is therefore excluded from the rest of the discussion.

The DAS consumption figures are calculated using the following relationship:

Equation 5-1

$$c_i = sl_i + ni_i - l$$

where

c_i	=	consumption of meat *i*
sl_i	=	slaughtering for meat *i*
ni_i	=	net imports of meat *i*
l	=	losses

The office of the Chief Meat Inspector from the DAPH supplies data on slaughterings. Slaughtering figures in this series are numbers of animals slaughtered for grades A to F summarised on a national level from abattoirs across the country. Two adjustments were made to slaughtering numbers. Firstly, it is assumed that slaughterings at abattoirs represent only the commercial sector of the meat industry. Accordingly, DAS adjusts slaughtering numbers to include the non-commercial sector, as well as slaughterings for own use. Secondly, DAS uses an average mass per carcass, based on historic data obtained from the former Meat Board, to transform slaughtering numbers into kilograms of meat slaughtered.

Net imports are based on customs and excise data from the SACU, including the BLNS (Botswana, Lesotho, Namibia and Swaziland) countries.

In practise it is impossible that everything that is slaughtered will be available for utilisation. Therefore, the DAS estimates include a ‘losses' factor calculated as a percentage of the quantity available for utilisation. From time to time this factor is benchmarked against surveys conducted in the past, as well as against information from the FAO.

In the case of SAMIC, consumption figures are based on:

Equation 5-2

$$c_i = sl_i + ni_i$$

as specified in equation 5-1.

As opposed to DAS, SAMIC does not adjust slaughtering numbers to include the non-commercial sector, as well as slaughterings for own use. They do, however, also transform slaughtering numbers into kilograms.

The DAS supplies SAMIC with import and export data. This means that SAMIC's net imports are also based on customs and excise data for the SACU, including the BLNS countries.

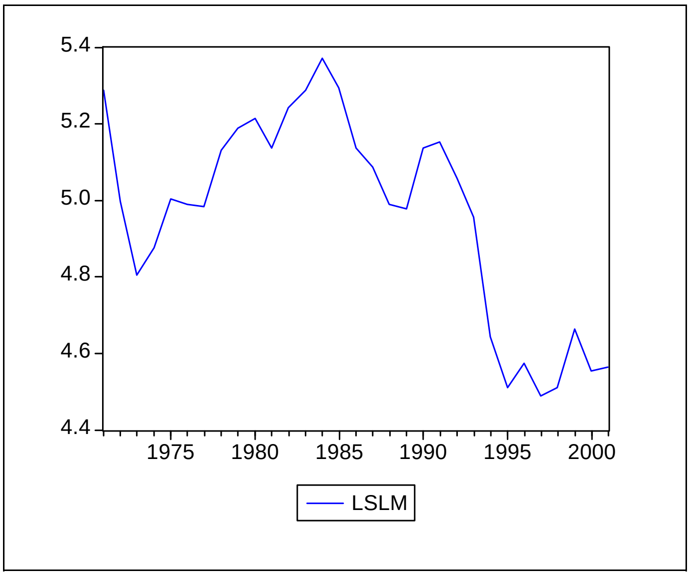
From the above comparison, it is evident that official data will deviate from private sector data. In order for the meat market model to balance, it is extremely important to standardise on either of the sources. Since the demand system of the sector model was based on Adam's (1998) estimations using consumption data supplied by the DAS, this study will, as far as it is possible, base the supply system estimation and the rest of its analysis on data supplied by the DAS.

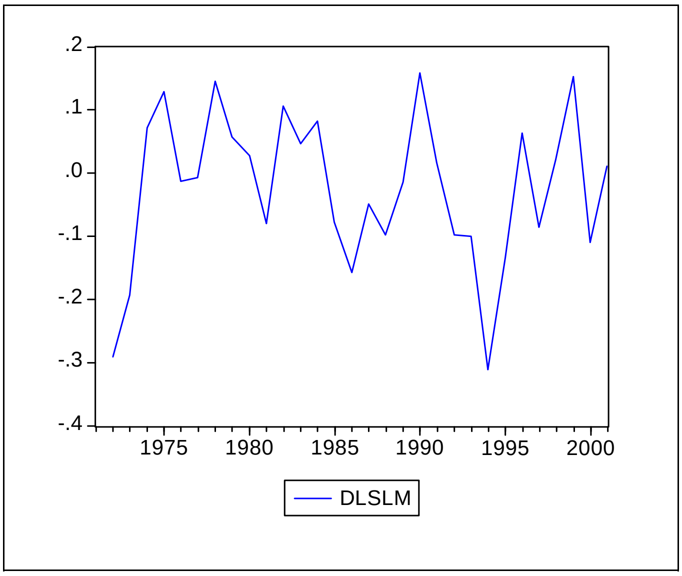
5.2 Analysis of univariate characteristics of data included in the final estimation results of the slaughtering system

As mentioned in section 4.4.1 ADF and PP unit root tests needs to be performed on the data to determine compliance with the stationarity assumption. Results from informal tests by plotting the data, in levels as well as in first differences (notated by D), are presented below. As double log functions were fitted, where possible, data series were used in natural logarithms (notated by L). Abbreviations presented in Figures 5-1 are used throughout section 5.3.

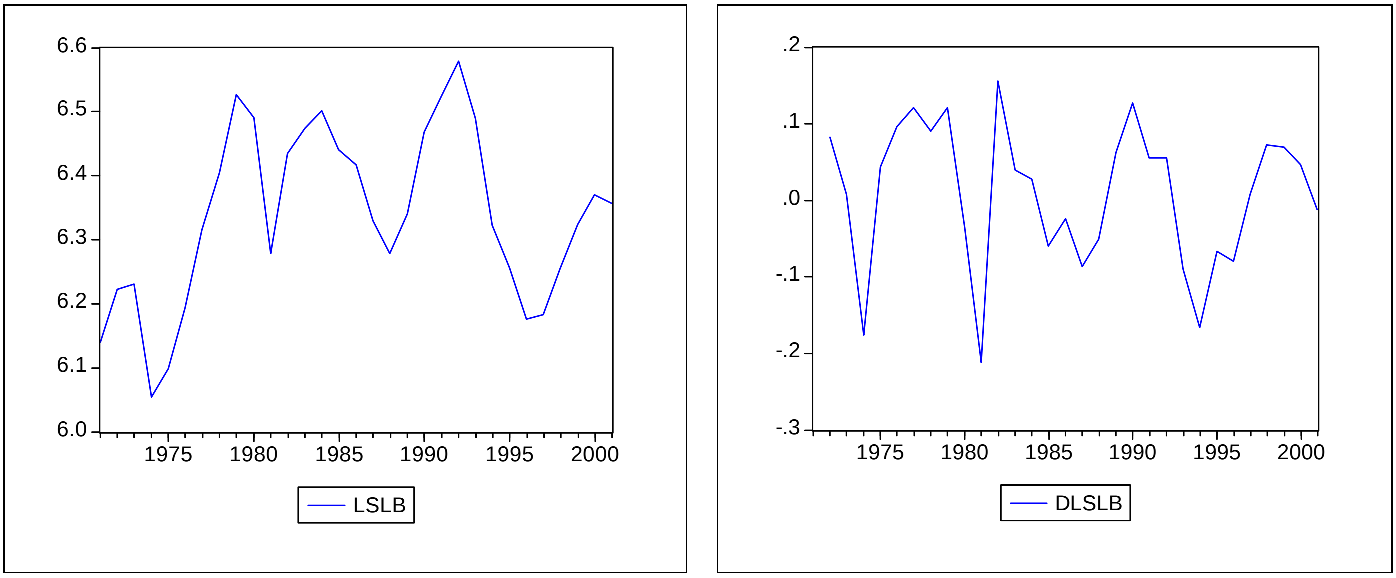
Figures 5-1. Slaughtering system data

<u>Slaughtering for mutton</u> (SLM)

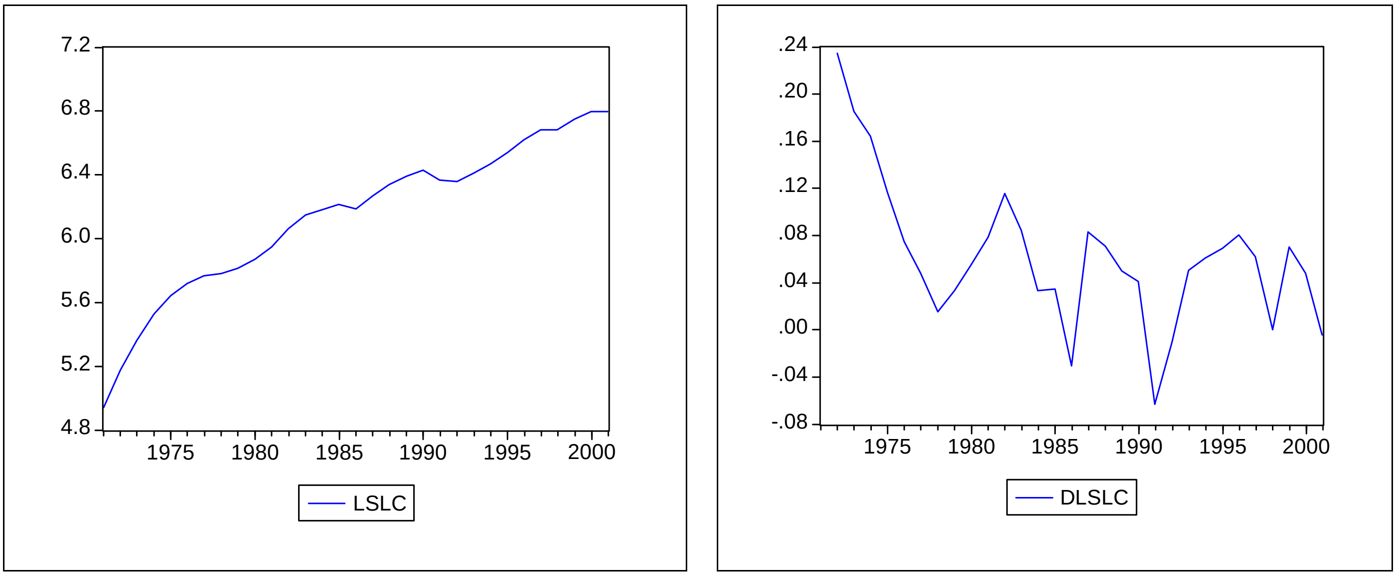




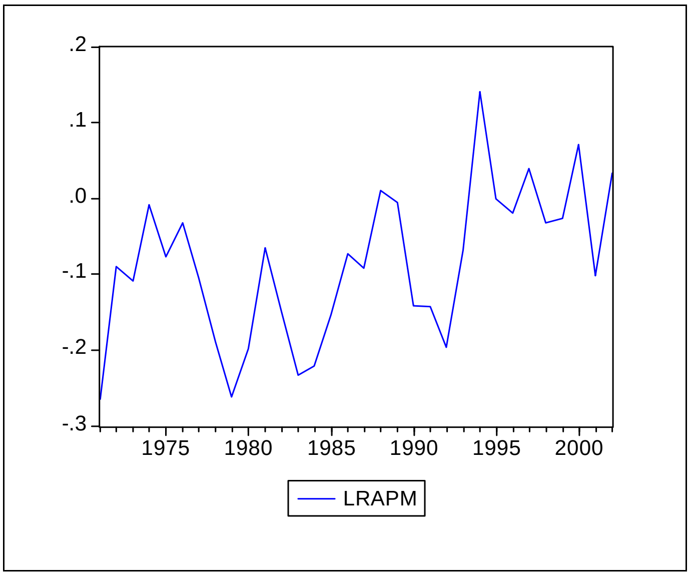
Slaughtering for beef (SLB)

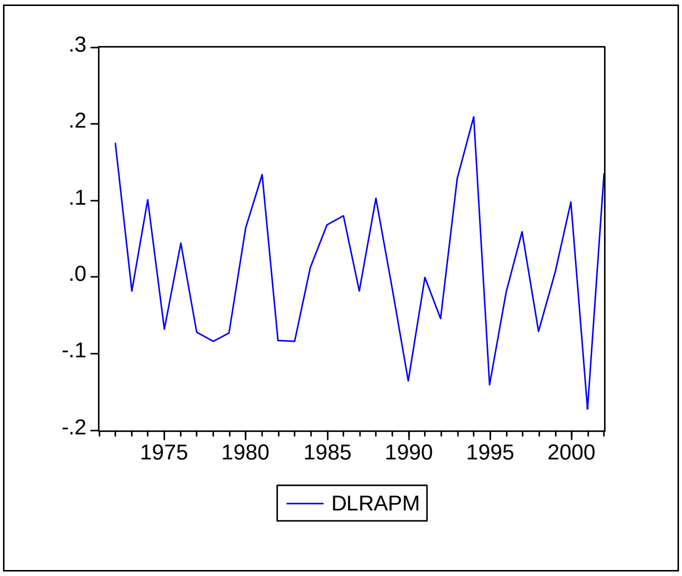


Slaughtering for chicken meat (SLC)

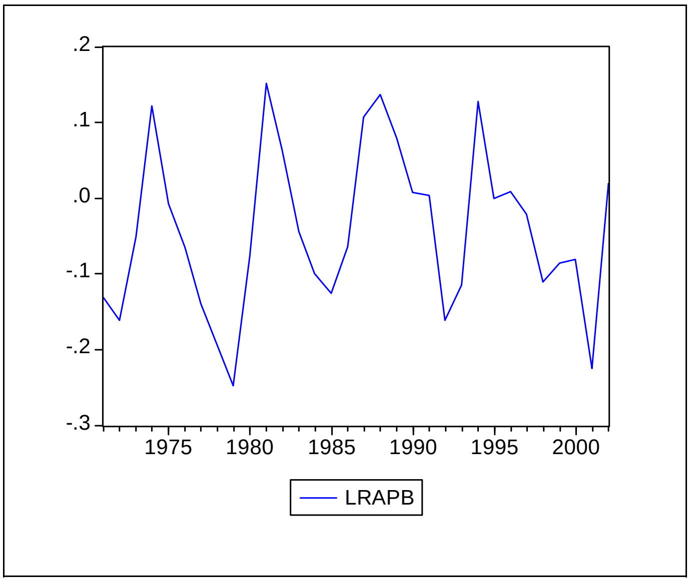


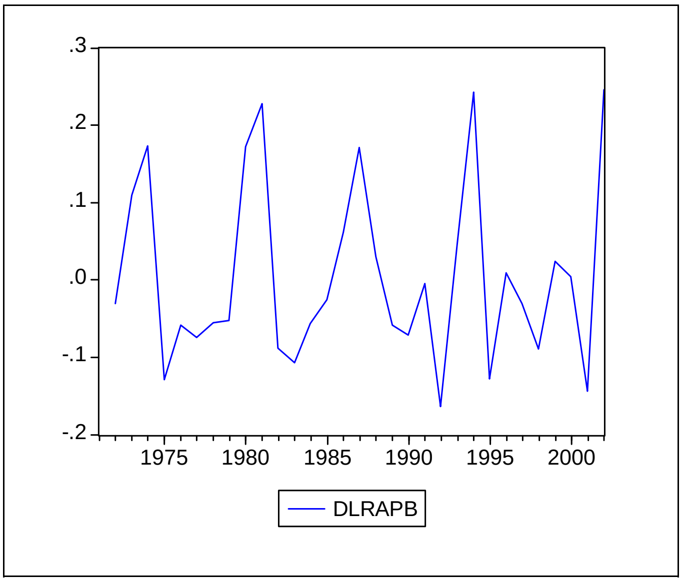
Real auction price of mutton (RAPM)



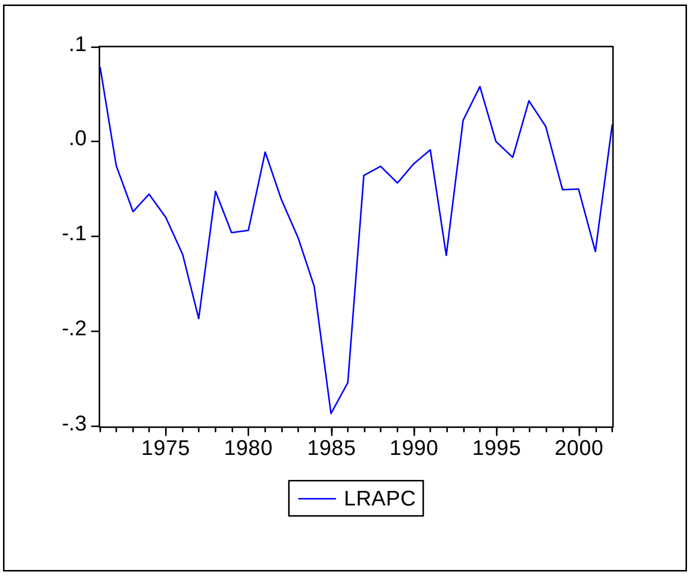


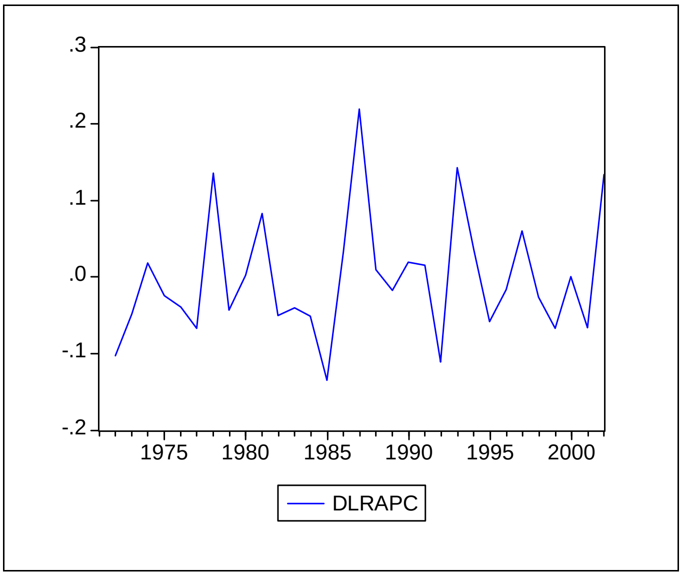
Real auction price of beef (RAPB)



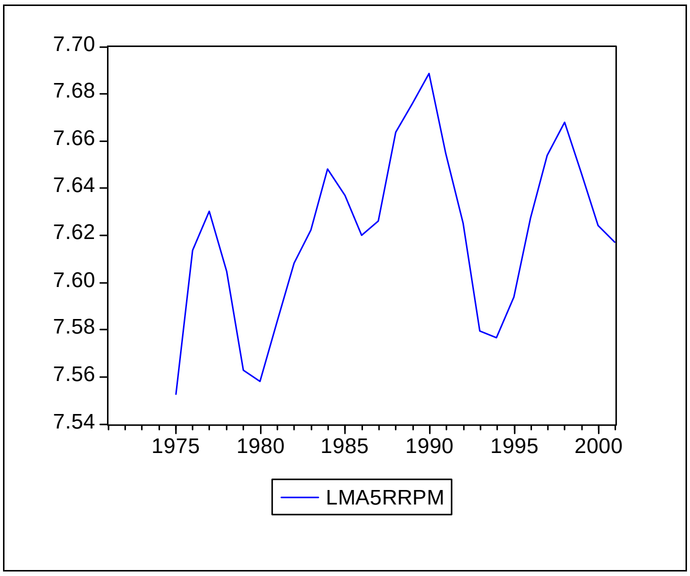


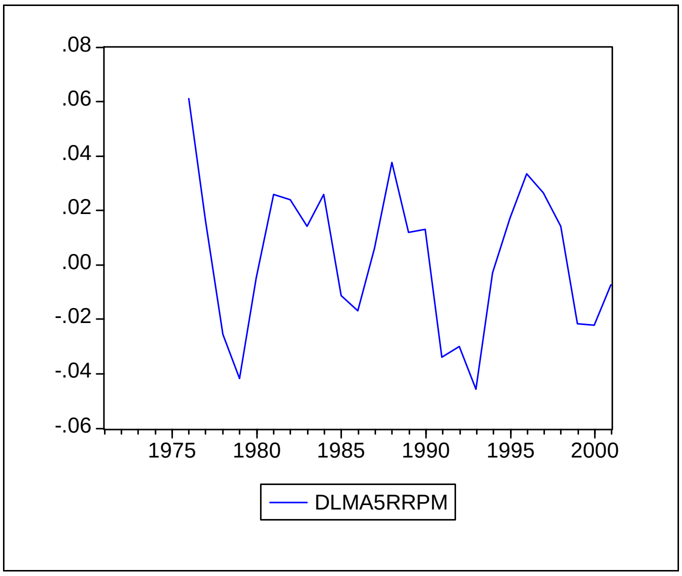
Real auction price of chicken meat (RAPC)



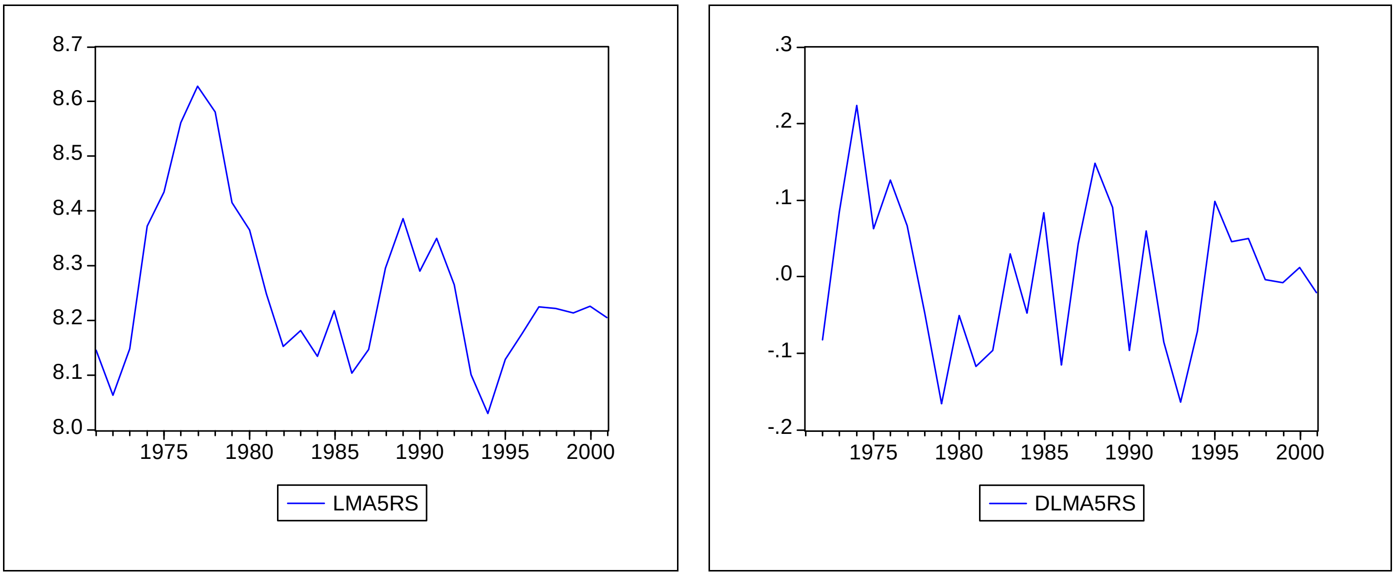


Five year moving average of the real retail price of mutton (MA5RRPM)

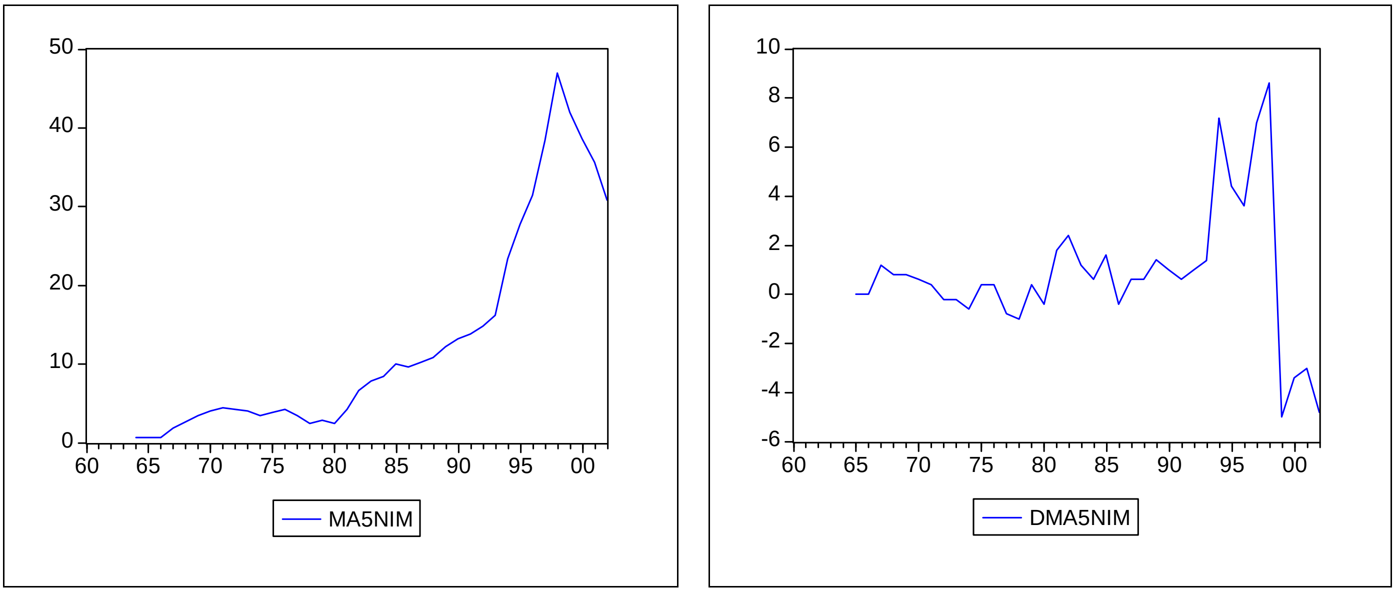




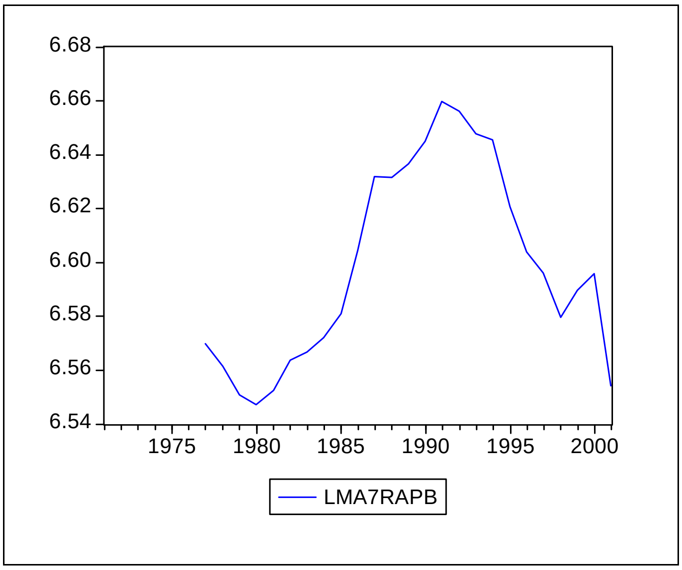
Five year moving average for rainfall in the sheep producing areas (MA5RS)

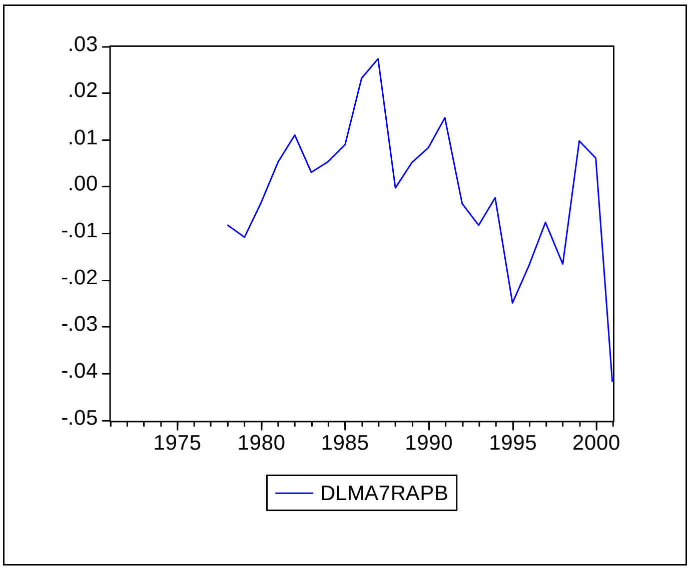


Five year moving average for the net imports of mutton (MA5NIM)

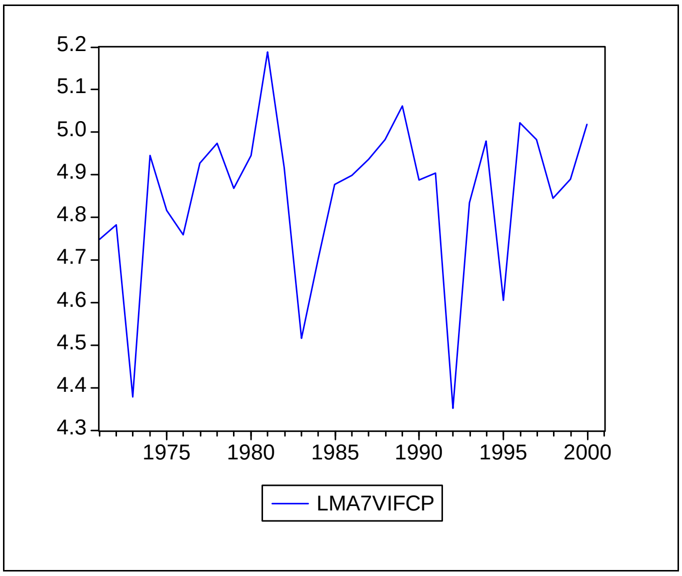


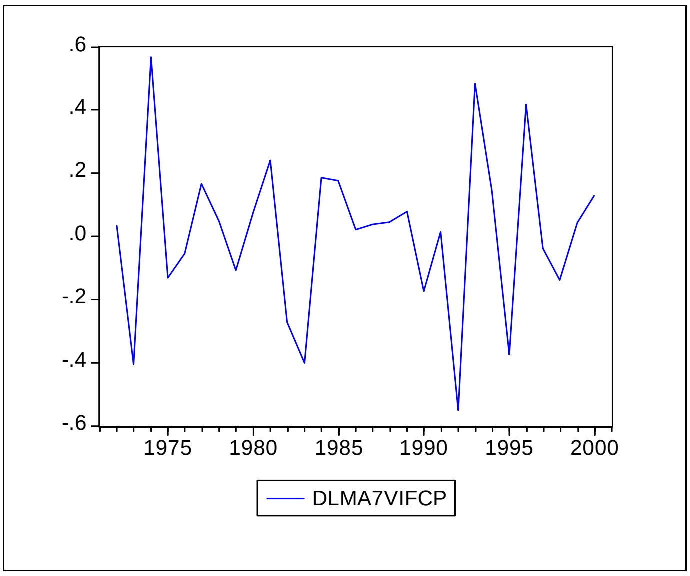
<u>Seven year moving average for the real auction price of beef</u> (MA7RAPB)



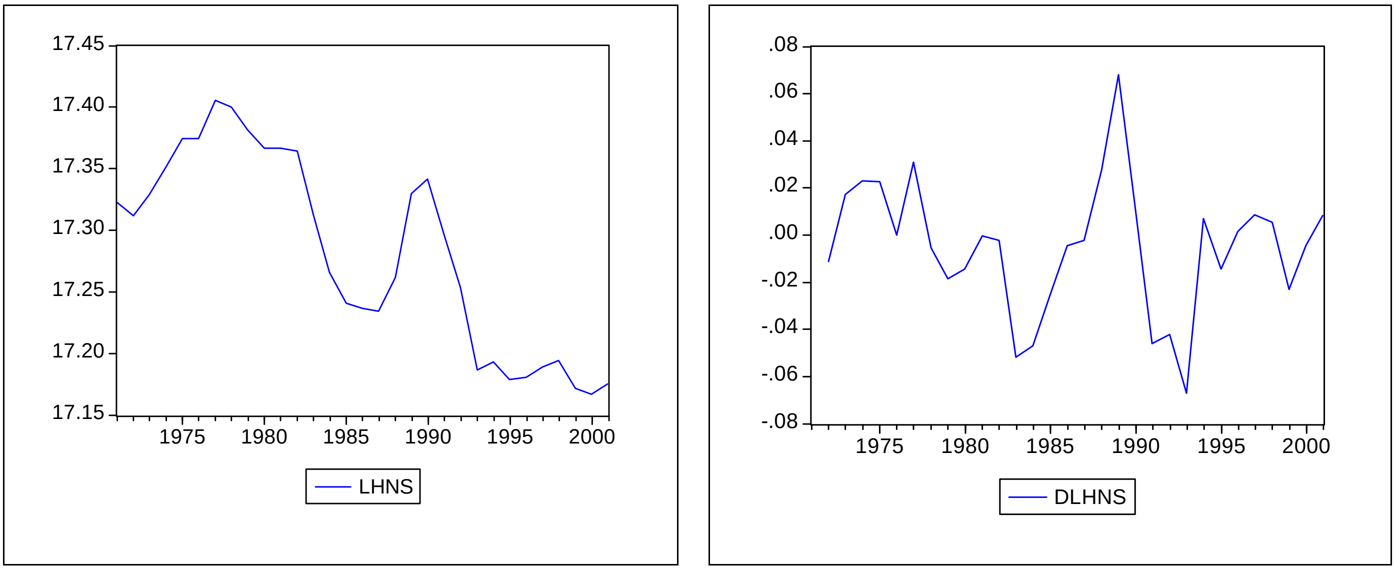


<u>Seven year moving average of the volume index for field crop production</u> (MA7VIFCP)

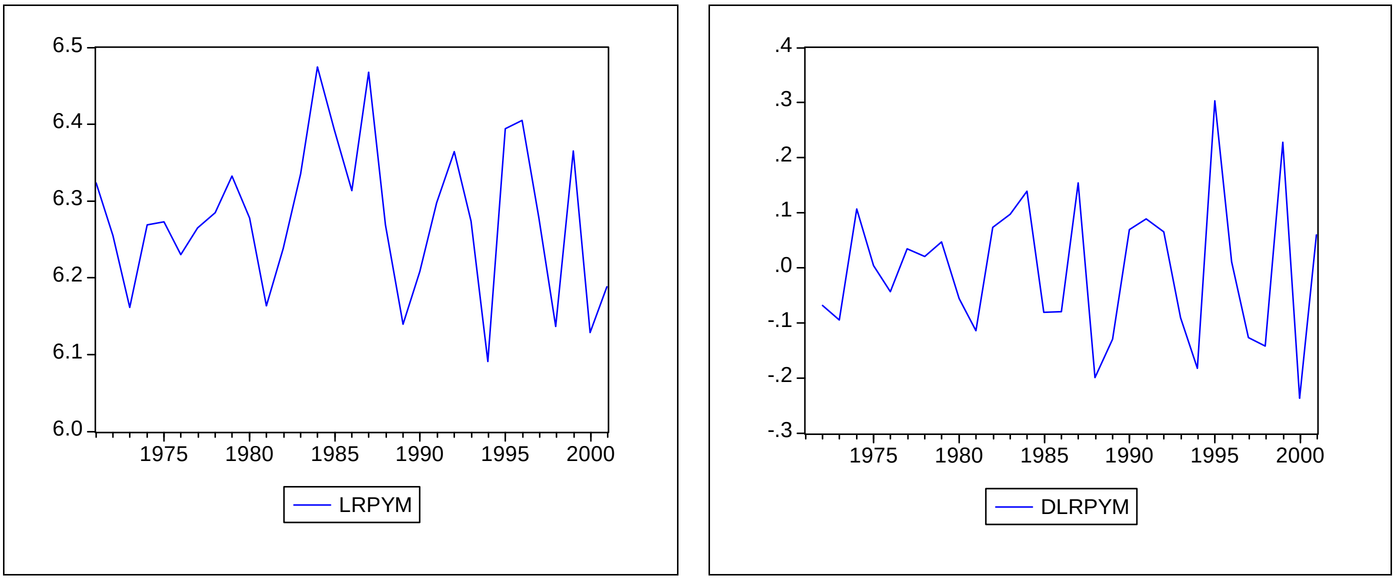




Heard numbers for sheep (HNS)



Real price of yellow maize (RPYM)



Results from formal ADF and PP tests are summarised in Table 5-1. From both the informal and the formal unit root tests it is evident that RAPM, RAPB, RAPC, MA7VIFCP and RPYM do not have any unit roots and are therefore stationary, while the rest of the variables have one or more unit roots and are therefore non-stationary. As regression analysis based on time series data assumes that the underlying time series is stationary, the non-stationarity of a number of the variables is a cause of concern.

Table 5-1. Formal unit root test results on slaughtering system data

Variable	Model	ADF Lags	τ_τ, τ_μ, τ	Φ_3, Φ_1	PP lags	PP
LSLB	t, c	1	-2.702	3.112	3	-2.269
	c	1	-2.741*	4.771	3	-2.384
	none	0	0.376		3	0.359
DLSLB	t, c	3	-4.032**	4.151	3	-3.991**
	c	0	-4.131***	17.064***	3	-4.073***
	none	0	-4.206***		3	-4.155***
LSLC	t, c	1	-3.167	13.428***	3	-5.139***
	c	1	-1.686	12.851***	3	-3.821***
	none	1	1.623		3	3.401
DLSLC	t, c	0	-3.478*	6.450***	3	-3.446*
	c	0	-3.450**	11.901***	3	-3.493**
	none	0	-3.054***		3	-3.143***
LRAPM	t, c	0	-3.811**	7.289***	3	-3.874**
	c	0	-3.376**	11.394***	3	-3.410**
	none	0	-2.793***		3	-2.782***
DLRAPM	t, c	0	-7.033***	24.761***	3	-9.115***
	c	0	-7.118***	50.661***	3	-9.163***
	none	0	-7.111***			-8.055***
LRAPB	t, c	3	-4.496***	5.150***	3	-3.081
	c	3	-4.306***	5.929***	3	-3.172**
	none	1	-4.173***		3	-3.054***
DLRAPB	t, c	3	-5.923***	11.949***	3	-6.202***
	c	3	-5.448***	13.047***	3	-5.935***
	none	3	-5.241***		3	-5.875***
LRAPC	t, c	0	-3.674**	7.280***	3	-3.638**
	c	0	-3.289**	10.816***	3	-3.347**
	none	1	-2.089**		3	-2.360**
DLRAPC	t, c	0	-5.724***	16.394***	3	-6.944***
	c	0	-5.777***	33.369***	3	-6.926***
	none	1	-5.405***		3	-7.156***
LMA5RRPM	t, c	3	-1.824	7.610**	2	-2.621
	c	3	-2.066	9.995**	2	-2.767*
	none	3	0.922		2	0.460
DLMA5RRPM	t, c	2	-5.273***	7.253***	2	-3.395*
	c	2	-5.282***	9.569***	2	-3.529**
	none	2	-5.222***		2	-3.631***
LMA5RS	t, c	3	-3.872***	3.669	3	-2.325
	c	1	-2.825*	5.484	3	-2.138
	none	0	0.082		3	0.065
DLMA5RS	t, c	0	-3.974**	7.967***	3	-4.005**
	c	0	-3.951***	15.607***	3	-3.981***
	none	0	-4.014***		3	-4.043***
MA5NIM	t, c	2	-4.113**	5.057	2	-2.527
	c	0	-0.366	0.134	2	-0.492
	none	0	1.971		2	1.592
DMA5NIM	t, c	0	-3.551*	6.331***	2	-3.555*
	c	3	-3.404**	4.670	2	-3.636**
	none	0	-3.264***		2	-3.245***

Variable	Model	ADF Lags	ττ, τμ, τ	Φ3, Φ1	PP lags	PP
LMA7RAPB	t, c	0	0.255	1.730	2	-0.025
	c	3	-2.234	3.096	2	-1.025
	none	1	-0.287		2	-0.179
DLMA7RAPB	t, c	0	-2.658	4.432	2	-2.140
	c	0	-2.156	4.649	2	-2.112
	none	0	-2.238**		2	-2.187**
LMA7VIFCP	t, c	0	-4.839***	11.715***	3	-4.839***
	c	0	-4.809***	23126***	3	-4.809***
	none	2	0.615		3	0.269
DLMA7VIFCP	t, c	1	-7.070***	28.504***	3	-10.747***
	c	1	-7.150***	43.71***	3	-11.073***
	none	1	-7.213***		3	-11.170***
LHNS	t, c	1	-4.053**	9.245***	3	-2.475
	c	1	-1.375	4.592	3	-0.518
	none	1	-0.468		3	-0.802
DLHNS	t, c	0	-3.153	4.975	3	-2.923
	c	0	-3.161**	9.993***	3	-2.942**
	none	0	-3.175***		3	-3.106***
LRPYM	t, c	0	-4.408***	9.723***	3	-4.326***
	c	0	-4.485***	20.113***	3	-4.411***
	none	2	-0.032		3	-0.672
DLRPYM	t, c	2	-5.286***	16.849***	3	-15.135***
	c	1	-6.638***	33.106***	3	-13.070***
	none	1	-6.771***		3	-13.217***

Note: *** to mark the level of significance, * for 10%, ** for 5% and *** for 1%

Several problems are related to unit root tests, two of which are of concern in this analysis. The most important being the trade off between size and power, the other being their low power in the presence to structural breaks. To determine the presence of structural breaks the data was also subjected to stability tests by regressing each variable over time and performing the Ramsey Reset test (Table 5-2).

Table 5-2. Stability test results on slaughtering system data

Variables	RESET statistic
LSLB	33.919***
LSLC	31.677***
LRAPM	14.677***
LRAPB	1.898
LRAPC	11.953***
LMA5RRPM	160.094***
LMA5RS	34.819***
LMA5NIM	44.270***
LMA7RAPB	150.448***
LMA7VIFCP	30.456***
LHNS	33.133***
LRPYM	31.967***

Note: *** to mark the level of significance, * for 10%, ** for 5% and *** for 1%

The stability test results from Table 5-2 suggest that structural breaks are present in almost all of the variables, placing the validity of the unit root tests under suspicion. Based on these findings it is assumed that all variables are stationary and that it is possible to continue with classical OLS estimation techniques.

5.3 Results of the empirical analysis of meat slaughtering in SA

5.3.1 Single equation estimation results for slaughtering equations

In an attempt to increase the number of observations, initial estimations were based on monthly data. Due to problems with stationarity and serial correlation final results are however, based on yearly data.

All nominal prices were adjusted to real prices (notated by R) in order to remove the effect of inflation and expressed in index form (notated by I). Retail prices were adjusted with the CPI and producer prices with the producer price index (PPI) for agricultural products. The option of adjusting producer prices with the CPI was also considered as it is argued that production decisions are also influenced by factors such as marketing and transport costs.

In cases where breaks were justifiable according to applied theory and where variables were stationary before and after breaks, dummy variables representing these breaks were included in the model specification along with constants and linear trends in the beginning of the top-down approach. A structural break in 1994 was tested in the supply of mutton estimation, as it is believed that the first democratic election of 1994, which brought the African National Congress to power demarcated structural changes in the agricultural sector. The sector changed from being under a high degree of control to operating independently in a market driven environment. This break proved to be insignificant and was dropped from the model. Another structural break in 1975 was tested in the supply of beef equation. According to Janovsky (2003) technological improvements, such as the utilisation of fencing and auction management, as well as improvements in tractors and fertilisers contributed to an upward trend in the availability of natural resources. Around the middle seventies production technology reached its plateau, natural resources were being utilised optimally and beef production stagnated.

Because time and weather are important factors to be incorporated in the specification, the estimation process becomes very complicated. In some cases meat producers are expected not only to base their decision on the current level of different variables, but also on the lagged effect of some regressors. Given the time frames associated with the different production cycles of the meat industries it is expected that mutton, beef and pork producers will, respectively, take up to 5, 7 and 3 years to implement new decisions, but also that they do not base there production decisions on a single year only. Instead, it is believed that the decision to slaughter is based on information over several years. The method of moving averages assumes that equal weights are allocated to the number of years chosen. In the case of chicken meat production, time lags are believed not to play an important role in decision-making, as the production cycle is relatively short. Different options and combinations of these lags were tested in the estimation process and only those that realised the best results were included in the final analysis. (Lags are notated as (-y) and moving averages as MAy, where y is the number of years.)

It is expected that meat producers are very aware of the different meat prices and are, accordingly, expected to also consider relative prices rather than absolute prices. Different options were tested in the estimation process. None of the relative price variables, however, remained in the final results.

Despite the insignificance of the intercept in the various regressions, it is rettained in all final estimations as Gujarati (1995) warns that the intercept should only be excluded in cases where there is a very strong a priory expectation and as the unit root tests indicated that the intercept should be included.

First order serial correlation was detected in all cases. In the presence of first-order serial correlation, the application of a first-order autoregressive scheme [AR(1)] corrects for this problem. The results of the AR(1) model, however, drastically influenced multicollinearity as well as the statistical significance of various variables. Despite important statistical shortcomings caused by the violation of this assumption, it was decided not to correct for first-order serial correlation.

As mentioned before, the structure of the agricultural sector changed dramatically from being highly dependent on government regulation to being mainly market driven and by the end of 1996 most of the agricultural industry boards were abolished. Data collection structures in the agricultural sector mainly took place through these industry boards. Although most of the data collection functions were eventually taken over by interested parties, accuracy of the actual data was lost due to the disruption. Two samples were applied, namely, the period 1971 to 1996, as well as the period 1971 to 2002. Despite the suspected shortcomings in the data, last mentioned sample realised the best results.

5.3.1.1 Slaughterings for mutton

Table 5-3 presents the best fit of the slaughterings for mutton single equation estimation and Table 5-4 shows results of the battery of diagnostic tests applied.

Table 5-3. Slaughtering for mutton single equation estimation results

Dependent Variable: LSLM				
Method: Least Squares Date: 05/01/04 Time: 10:00 Sample(adjusted): 1975 2002 Included observations: 28 after adjusting endpoints				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LMA5RRPMI	2.554110	0.482642	5.291936	0.0000
LRAPBI	-0.343541	0.182115	-1.886392	0.0731
LHNS(-2)	1.284589	0.467087	2.750213	0.0120
LMA5RS	-0.605853	0.130674	-4.636360	0.0001
MA5NIM	-0.016947	0.002958	-5.728846	0.0000
LRAPMI(-5)	0.168704	0.192723	0.875368	0.3913
C	-12.02416	8.168171	-1.472075	0.1558

R-squared	0.935252	Mean dependent var	4.943113
Adjusted R-squared	0.916753	S.D. dependent var	0.285732
S.E. of regression	0.082441	Akaike info criterion	-1.941146
Sum squared resid	0.142727	Schwarz criterion	-1.608094
Log likelihood	34.17604	F-statistic	50.55569
Durbin-Watson stat	1.275647	Prob(F-statistic)	0.000000

Table 5-4. Diagnostic test results of the slaughtering for mutton equation

Test for	Test	Test Statistic	p-value	Conclusion
Normality	JB	0.406	0.816	Errors normally distributed
Serial correlation	DW	1.276		Positive serial correlation
	LM(2)	2.583	0.275	No serial correlation
	LM(3)	2.584	0.460	No serial correlation
Heteroscedasticity	ARCH(1)	0.002	0.960	No heteroscedasticity
	ARCH(2)	0.042	0.979	No heteroscedasticity
	ARCH(3)	0.767	0.857	No heteroscedasticity
	White(10)	16.351	0.176	No heteroscedasticity

All the variables are independently significant, except for the intercept and RAPM(-5), which, never the less, retained in the model being key variables for further analysis. Ninety four percent of the variation in SLM was explained by the variation in the explanatory variables and the F-statistic of 51 indicates that all the variables were jointly significant in explaining the SLM.

A mutton producers' decision to slaughter is therefore influenced by, the real own price the retailer realised over the past five years (MA5RRPM); the real price the beef producer realised in that same year (RAPB); the number of stock kept two years ago (HNS(-2)); the amount of rain that fell in the region, on average, during the last five years (MA5RS); the degree of exposure to international trade, on average, during the last five years (MA5NIM); and the real own price the producer realised five years ago (RAPM(-5)).

Signs of the estimated coefficients were consistent with expectations, showing that slaughterings increase with the auction and retail price of mutton, but decrease with the auction price of other meat products. Sheep slaughterings were also found to increase with larger herd numbers two years ago, but decrease with good rainfall. This is an indication that as grazing conditions improve producers tend to use the opportunity to build stocks. Sheep slaughterings were found to decrease with higher exposure to world markets (higher net imports).

As double log functions were fitted, the coefficients in Table 5-3, with the exception of the coefficient for MA5NIM, are also the elasticities. The variable, MA5NIM, was fitted in levels as it contained negative values. Accordingly, its elasticity was calculated to be 0.218. Slaughterings for mutton is inelastic with respect to, RAPB, MA5RS, MA5NIM and RAPM(-5) and elastic with respect to MA5RRPM and HNS(-2).

5.3.1.2 Slaughterings for beef

Table 5-5 presents the best fit of the slaughterings for beef single equation estimation and Table 5-6 applies a battery of diagnostic tests.

Table 5-5. Slaughtering for beef single equation estimation results

Dependent Variable: LSLB				
Method: Least Squares Date: 05/01/04 Time: 13:02 Sample(adjusted): 1974 2002 Included observations: 29 after adjusting endpoints				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LMA7RAPBI	0.698857	0.363886	1.920539	0.0673
LRAPMI	-1.038192	0.118429	-8.766376	0.0000
LRAPCI(-3)	-0.276240	0.135503	-2.038627	0.0531
LRPYMI(-7)	0.364291	0.132045	2.758850	0.0112
LMA7VIFCP	0.753397	0.115683	6.512607	0.0000
C	2.631126	0.567709	4.634637	0.0001

R-squared	0.853384	Mean dependent var	6.353365
Adjusted R-squared	0.821511	S.D. dependent var	0.132678
S.E. of regression	0.056054	Akaike info criterion	-2.743021
Sum squared resid	0.072266	Schwarz criterion	-2.460132
Log likelihood	45.77381	F-statistic	26.77455
Durbin-Watson stat	1.802466	Prob(F-statistic)	0.000000

Table 5-6. Diagnostic test results for the slaughtering for beef equation

Test for	Test	Test Statistic	p-value	Conclusion
Normality	JB	0.967	0.617	Errors normally distributed
Serial correlation	DW	1.802		Positive serial correlation
	LM(2)	3.631	0.163	No serial correlation
	LM(3)	4.498	0.212	No serial correlation
Heteroscedasticity	ARCH(1)	0.093	0.760	No heteroscedasticity
	ARCH(2)	0.478	0.787	No heteroscedasticity
	ARCH(3)	4.498	2.25	No heteroscedasticity
	White(10)	9.617	0.382	No heteroscedasticity

All the variables were independently significant. Eighty five percent of the variation in SLB was explained by the variation in the explanatory variables and the F-statistic of 27 indicates that all the variables were jointly significant in explaining the SLB.

The beef producer's decision to slaughter is influenced by, on average, the combined real own price in the past seven years (MA7RAPB), the current real price for mutton producers received for their products (RAPM), the real price for chicken meat producers received for their products three years ago (RAPC(-3)), the real price paid for yellow maize seven years ago (RPYM(-7)) and, on average, the combined seven year effect of the quality of grazing (MA7VIFCP).

Only some signs of the estimated coefficients were consistent with expectations. As in the case of mutton, slaughterings increased with the price the producer receives for his product, but decrease with the producer price of other meat substitutes. The positive relationship between beef slaughterings and the price of yellow maize was consistent with expectations. As production costs increases, slaughterings needs to increase to cover the costs. This can be explained by the fact that higher feed prices push the cost of keeping larger stocks upward and hence provide an incentive to reduce stocks through increased slaughtering. On the other hand, the positive relationship with quality of grazing was inconsistent with expectations. This may be attributed to quality of the data available to support specification of more appropriate indicator of grazing quality.

Slaughterings for beef is inelastic with respect to MA7RAPB, RAPC(-3), RPYM(-7) and MA7VIFCP and elastic with respect to RAPM.

5.3.1.3 Slaughterings for pork

Table 5-7 presents the best fit of the slaughterings for pork single equation estimation and Table 5-8 reports on the battery of diagnostic tests performed.

Table 5-7. Slaughtering for pork single equation estimation results

Dependent Variable: LSLP				
Method: Least Squares Date: 05/03/04 Time: 09:29 Sample(adjusted): 1971 2002 Included observations: 32 after adjusting endpoints				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LMA3RAPBI	0.519674	0.146966	3.536026	0.0014
LMA3RAPPI	-1.016420	0.262931	-3.865721	0.0006
LTT	0.124462	0.013153	9.462699	0.0000
C	4.482155	0.047828	93.71347	0.0000

R-squared	0.851151	Mean dependent var	4.667569
Adjusted R-squared	0.835203	S.D. dependent var	0.147644
S.E. of regression	0.059937	Akaike info criterion	-2.674593
Sum squared resid	0.100587	Schwarz criterion	-2.491376
Log likelihood	46.79348	F-statistic	53.37012
Durbin-Watson stat	0.864124	Prob(F-statistic)	0.000000

Table 5-8. Diagnostic test results for the slaughtering for pork equation

Test for	Test	Test Statistic	p-value	Conclusion
Normality	JB	0.013	0.994	Errors normally distributed
Serial correlation	DW	0.864		Negative serial correlation
	LM(2)	12.375	0.002	Serial correlation
	LM(3)	13.933	0.003	Serial correlation
Heteroscedasticity	ARCH(1)	1.884	0.170	No heteroscedasticity
	ARCH(2)	2.620	0.270	No heteroscedasticity
	ARCH(3)	4.729	0.193	No heteroscedasticity
	White(10)	11.405	0.077	No heteroscedasticity

The slaughterings for pork equation did not pass the full battery of diagnostic tests that was performed. First, second and third order serial correlation were present.

All the remaining variables were independently significant. Eighty five percent of the variation in SLP was explained by the variation in the explanatory variables and the F-statistic of 53 indicates that all the variables were jointly significant in explaining the SLP.

The pork producer's decision to slaughter is influenced by, on average, the combined real own price of the past 3 years (MA3RAPP), as well as that of beef (MA3RAPB). The time trend (TT) captures the effect of time on production decisions.

The negative relationship of pork slaughterings with own price and the positive relationship with the price of other meat products were inconsistent with expectations. The positive relationship between slaughterings and time was also consistent with expectations, as it was expected that slaughterings would increase, as more time is available. Slaughterings for pork is inelastic with respect to MA3RAPB and TT and elastic with respect to MA3RAPP.

Due to the fact that higher-order serial correlation is present in the model and the sign of a key variable is in contrast with what is expected according to economic theory, it was decided not to use the pork supply estimation in further analysis.

5.3.1.4 Slaughterings for chicken meat

Table 5-9 presents the best fit of the slaughterings for chicken meat equation estimation and Table 5-10 applies the battery of diagnostic tests.

Table 5-9. Slaughtering for chicken meat single equation estimation results

Dependent Variable: LSLC				
Method: Least Squares Date: 05/03/04 Time: 10:59 Sample(adjusted): 1971 2002 Included observations: 32 after adjusting endpoints				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LRAPMI	0.499723	0.204929	2.438513	0.0216
LRAPBI	-0.369271	0.171338	-2.155222	0.0402
LRAPCI	0.407782	0.205732	1.982097	0.0577
LTT	0.544723	0.019895	27.37940	0.0000
C	4.822401	0.060044	80.31430	0.0000

R-squared	0.973936	Mean dependent var	6.159342
Adjusted R-squared	0.970075	S.D. dependent var	0.491260
S.E. of regression	0.084983	Akaike info criterion	-1.950132
Sum squared resid	0.194997	Schwarz criterion	-1.721111
Log likelihood	36.20211	F-statistic	252.2272
Durbin-Watson stat	0.618166	Prob(F-statistic)	0.000000

Table 5-10. Diagnostic test results for the slaughtering for chicken meat equation

Test for	Test	Test Statistic	p-value	Conclusion
Normality	JB	0.314	0.855	Errors normally distributed
Serial correlation	DW	0.618		Negative serial correlation
	LM(2)	13.601	0.001	Serial correlation
	LM(3)	13.993	0.003	Serial correlation
Heteroscedasticity	ARCH(1)	3.671	0.055	No heteroscedasticity
	ARCH(2)	9.867	0.007	Heteroscedasticity
	ARCH(3)	9.520	0.023	Heteroscedasticity
	White(10)	19.855	0.011	Heteroscedasticity

The slaughtering for chicken meat equation only passed the normality test. First, second and third order serial correlation, as well as heteroscedasticity were present.

All the remaining variables were independently significant. Ninety seven percent of the variation in SLC was explained by the variation in the explanatory variables and the F-statistic of 252 indicates that all the variables were jointly significant in explaining the SLC.

The chicken meat producer's decision to slaughter is influenced by the real own price (RAPC), as well as the price of mutton and beef (RAPM and RAPB). The time trend (TT) captures the effect of time on production decisions.

Only some of the signs of the estimated coefficients were consistent with expectations. As in the case of mutton and beef, slaughterings increase with the price the producer receives for his product, but decrease with the producer price of other meat products. The positive relationship between chicken meat slaughterings and mutton prices were inconsistent with expectations, indicating that these two are not necessarily substitutes but rather complements. As in the case of pork, the positive relationship between slaughterings and time, was, however, consistent with expectations, as it was expected that slaughterings will increase, as more time is available. Slaughterings for chicken meat is inelastic with respect to all of the variables.

Although the slaughterings for the chicken meat equation does not seem to be statistically sound, it was decided to include it in further analysis as the sign of it's key variables were in accordance with economic theory.

5.3.2 Slaughtering system estimation results

Variables giving the best single equation estimation results as presented in Tables 5-3, 5-5 and 5.9 were included in a meat slaughtering system, and the system estimation results are presented in Table 5-11.

Table 5-11. Meat slaughtering system estimation results

System: S_SLAUGHTERINGS				
Estimation Method: Seemingly Unrelated Regression Date: 05/08/04 Time: 08:26 Sample: 1971 2002 Included observations: 32 Total system (unbalanced) observations 89 Linear estimation after one-step weighting matrix				
	Coefficient	Std. Error	t-Statistic	Prob.
C(11)	-13.21197	6.383266	-2.069782	0.0421
C(12)	2.388628	0.379703	6.290787	0.0000
C(13)	-0.385669	0.149824	-2.574145	0.0121
C(14)	1.353461	0.365377	3.704288	0.0004
C(15)	-0.603011	0.103113	-5.848085	0.0000
C(16)	-0.017772	0.002327	-7.636962	0.0000
C(17)	0.244152	0.150107	1.626522	0.1083
Equation: LSLM = C(11) + C(12)*LMA5RRPMI + C(13)*LRAPBI + C(14) *LHNS(-2) + C(15)*LMA5RS + C(16)*MA5NIM + C(17)*LRAPMI(-5)				
C(21)	2.321709	0.486468	4.772581	0.0000
C(22)	0.610520	0.309913	1.969969	0.0527
C(23)	-1.033546	0.103742	-9.962637	0.0000
C(24)	-0.262446	0.115890	-2.264609	0.0266
C(25)	0.344501	0.112150	3.071788	0.0030
C(26)	0.815859	0.099183	8.225780	0.0000
Equation: LSLB = C(21) + C(22)*LMA7RAPBI + C(23)*LRAPMI + C(24) *LRAPCI(-3) + C(25)*LRPYMI(-7) + C(26)*LMA7VIFCP				
C(31)	4.846412	0.050681	95.62671	0.0000
C(32)	0.614109	0.176498	3.479410	0.0009
C(33)	-0.462061	0.150095	-3.078449	0.0030
C(34)	0.374853	0.173039	2.166288	0.0336
C(35)	0.537133	0.016934	31.71943	0.0000
Equation: LSLC = C(31) + C(32)*LRAPMI + C(33)*LRAPBI + C(34)*LRAPCI + C(35)*LTT				

All the identified variables from the single equation estimations remained statistically significant in the system estimation. Even RAPM(-5), in the case of the slaughtering for mutton equation, improved to an acceptable level of significance. The subsequent elasticities were in the same order as in the respective single equation estimations and they have now been accepted to be a better estimation. Accordingly, the results from the system estimation will be used in the rest of the analysis and policy simulations.

5.4 Comparison of this study results with available literature

The most recent and relatively comparable study from the literature was that of Lubbe (1992). Lubbe (1992) evaluated the controlled red meat marketing system. One of his goals was to determine production, efficiency of production and profitability of the mutton, beef and pork industries. In order to determine the efficiency of production he estimated supply equations for four different time periods with up to seven different dependent variables. Unforetunately, Lubbe (1992) only estimated supply with slaughterings as the dependent variable in the case of beef. Phase four which covered the period 1956 to 1990 were the most recent and in the case of beef presented a period of support prices (floor prices), supply control via permits and quotas and restrictive registration of the majority of participants (almost everybody except the consumer). Lubbe's beef supply estimates are presented in Table 5-12.

Table 5-12. Comparison of beef supply estimates

Lubbe (1992)		Present study	
Variable	**Estimate**	**Variable**	**Estimate**
Intercept	-879.40***	*Intercept*	2.322*
$Herd_{L1}$	-0.094***	*MA7RAPB*	0.611***
Rain	-2.197*	*RAPM*	-1.034*
$Rain_{L4}$	0.888**	*RAPC*	-0.262***
BF%	45.452*	*RPYM*	0.345*
R_Price	7.435*	*MA7VIFCP*	0.816****
R_Price_{L4}	8.659*		

* P < 0.001, ** P < 0.01, *** P < 0.05, **** P < 0.10

where

Slaught	=	Slaughterings of cattle (X 1000)
Herd	=	Population numbers of cattle (X 1000)
Rain	=	Yearly rainfall (1920 to 1990) in mm
BF%	=	Percentage of beef females in population (> 1 year)
R_Price	=	Real price of beef, mutton or pork (c/kg) deflated by the food price index (1989 = 100).

Lagged variables are denoted by a subscript L_i of lags *i* to *n*.

Lubbe (1992) found slaughterings to be negatively related to a one-year lag in the cattle population (a decrease in the cattle population will increase slaughterings), and the current rainfall level (withholding effect). Positive relationships existed with the rainfall level lagged four years, the present percentage of beef females in the herd, current real prices, and real prices lagged four years. It is obvious that slaughterings are largely determined by the interaction of the cyclical herd contraction / expansion and cyclic real price behaviour.

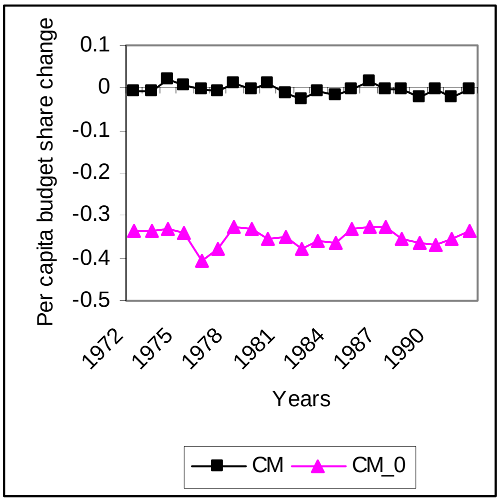
Compared to the meat slaughtering system estimation results of the present study, it is evident that the results of the two studies are completely different but not contradictory. Different explanatory variables were found to be significant in the present study, which might be explained by the fact that the structure of the industry changed from being regulated to being unregulated.

5.5 The meat sub-sector model

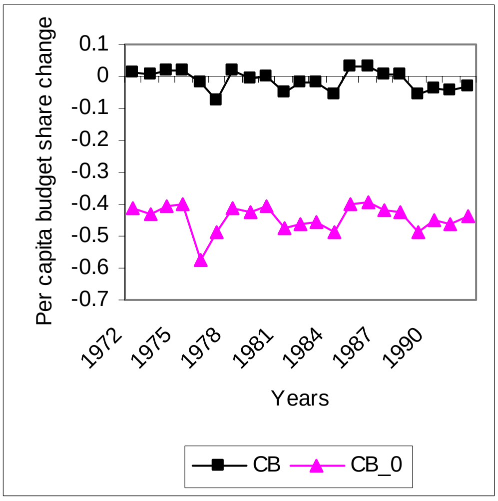
The initial meat and land multi-market model, as described in section 4.2 was reduced to a meat sub-sector model, as data for Van Schalkwyk's (1995) regional production functions (section 4.3.2) were unobtainable and Adam's (1998) meat demand system, despite its reported system wide R square of 82 percent, did not give good estimates in sample forecasts. Last mentioned was solved with the dynamic-deterministic simulation of the Gauss Seidel solution, which was based on ex post within the sample data (1976 – 1996) and is graphically presented below. From Figures 5-2 it is evident that there is an unacceptable gap between the actual and forecast (notated by _0) data.

Figures 5-2. In sample forecast of Adam's meat demand system

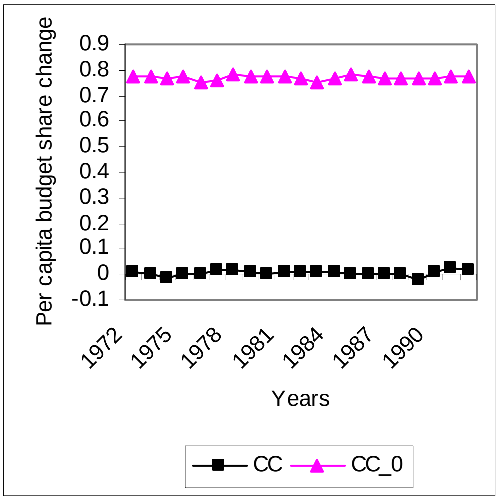
Consumption of mutton (CM)



Consumption of beef (CB)



Consumption of chicken meat (CC)



In order to bring about interaction between slaughterings of different meat industries in the meat sub-sector model, however, it was necessary to estimate an additional auction price system. This allows accounting for various demand factors indirectly through the price system.

5.5.1 Specification of the auction price system

As mentioned above, the purpose of estimating and using this system was to allow for major factors, mainly demand, to work through the producer (auction) price back into the amount of meat slaughtered domestically. Accordingly, producer (auction) prices were influenced (negatively) at equilibrium by total supply. Total supply includes domestic slaughterings and imports. Income, on the other hand, influences demand positively, which in turn influences market prices at clearing (equilibrium) positively, while producer prices follow the movements of market clearing prices. Changes in retail and import prices are expected to move auction prices in a similar direction (positive influence) and finally, auction prices are expected to trend upward. This trend is captured through a time variable.

As in the case of estimating the slaughtering system, the pragmatic approach was also adopted for estimating the auction price system. Both single equation and systems of equations estimation methods were applied. Different specifications of the following auction price model were estimated:

Equation 5-3

$$ap_i = f\left(ts_i, rdipc, rp_i, ip_i, tt\right)$$

where

ap_i	=	auction price of meat i
ts_i	=	total supply of meat i
$rdipc$	=	real disposable income per capita
rrp_i	=	retail price of meat i
rip_i	=	import price of meat i
tt	=	time trend

Table 5-13 summarises the data used in the specification of equation 5-3.

Table 5-13. Data description, calculation, unit of measure and source for auction price system

VARIABLE NAME	DESCRIPTION AND CALCULATION	UNITOF MEASURE	SOURCE
ap_i	auction price of meat *i* (*i* = mutton, beef, pork and chicken meat)	c/kg	DAS
ts_i	total supply of meat *i* $sl_i + iq_i$	1000 tons	calculated
sl_i	slaughterings for meat *i*	1000 tons	DAS
iq_i	import quantity of meat *i*	1000 tons	FAO
rdipc	real disposable income per capita	constant '95 prices	SARB* 6272y
rp_i	retail price of meat *i*	c/kg	Adam (1989) / SAMIC
ip_i	import price of meat *i* $iv_i / iq_i) / er$	c/kg	calculated
iv_i	import value of meat *i*	1000 US$	FAO
er	exchange rate	SA cents per US$	SARB KBP5339J

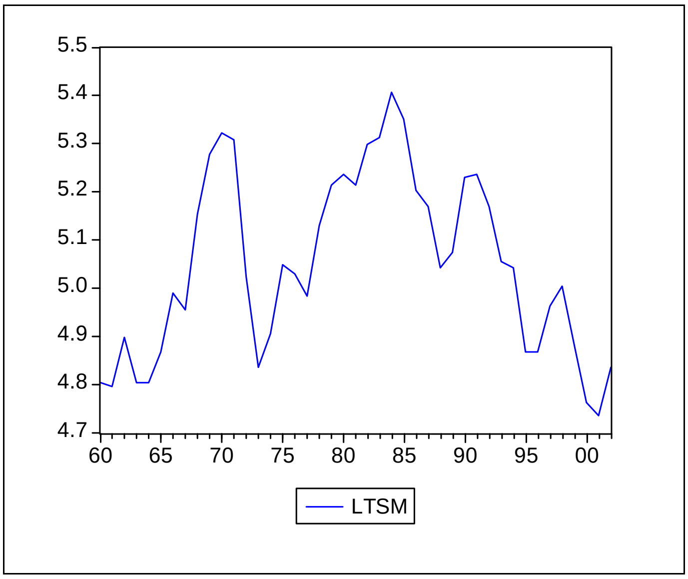
*SA Reserve Bank (SARB)

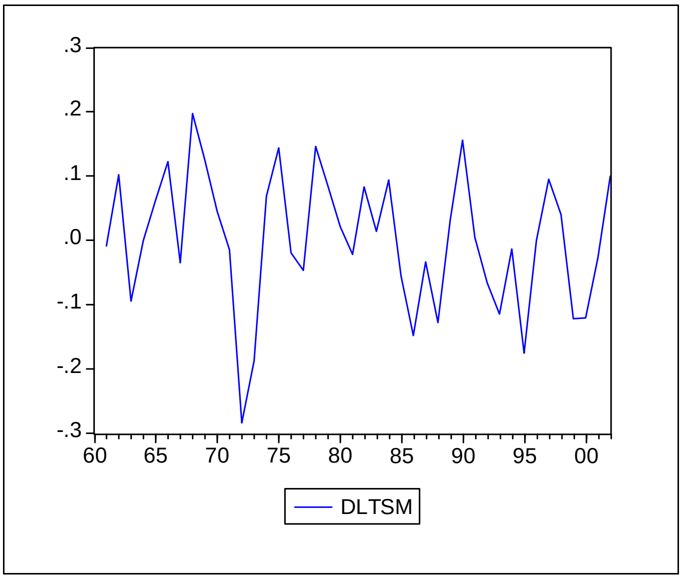
5.5.2 Analysis of the univariate characteristics of data included in the final estimation results of the auction price system

The analysis of the univariate characteristics of data presented here covers additional data used in the auction price system that was not analysed in section 5.2. As in the case of the slaughtering system, it was decided to use classical OLS estimation techniques. Again data plots, formal ADF and PP unit root (Table 5-14) and stability (Table 5-15) tests were performed on the data. Data plots, in levels as well as in first differences (notated by D), are presented below. As double log functions were fitted, where possible, data series were used in natural logarithms (notated by L). Abbreviations presented in Figures 5-3 are used throughout section 5.5.3.

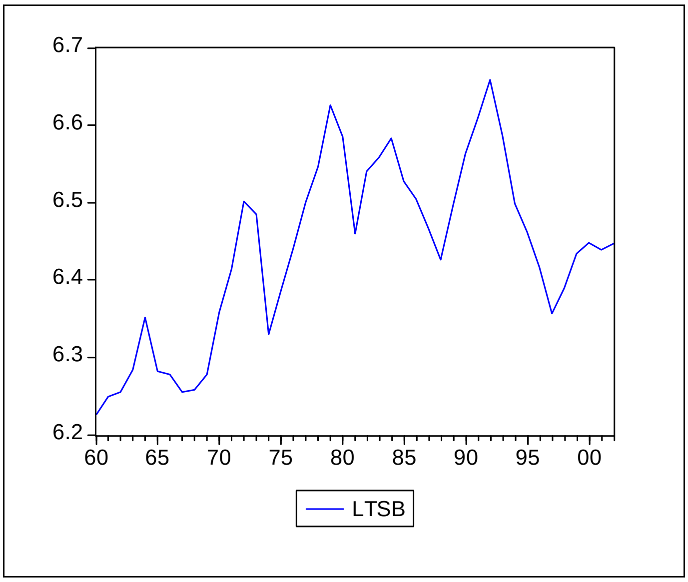
Figures 5-3. Auction price system data

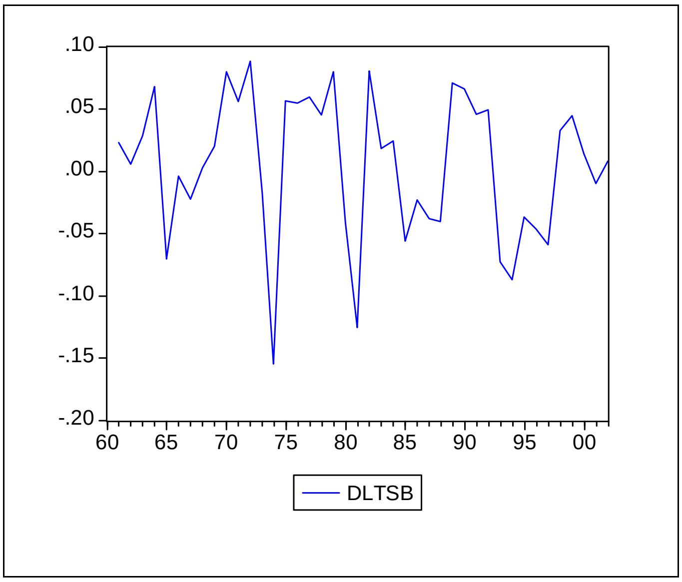
Total supply of mutton (TSM)



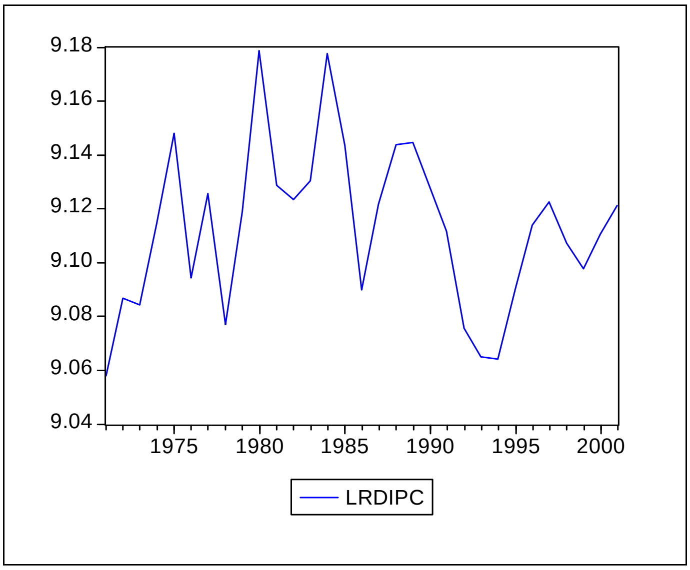


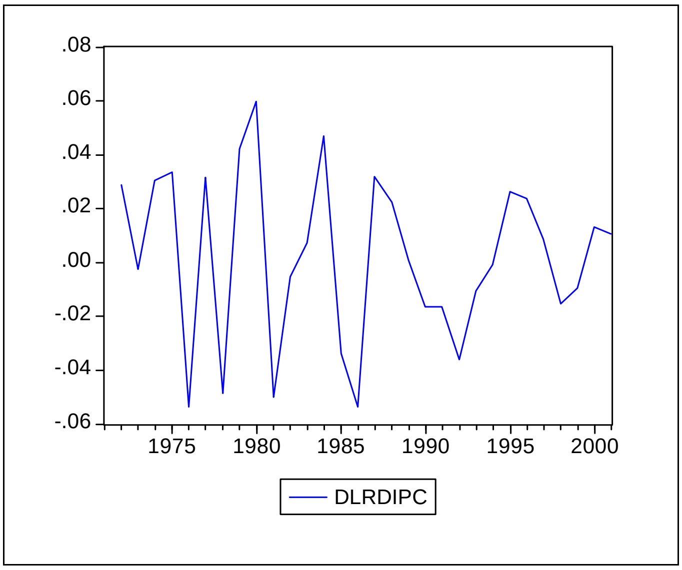
Total supply of beef (TSB)



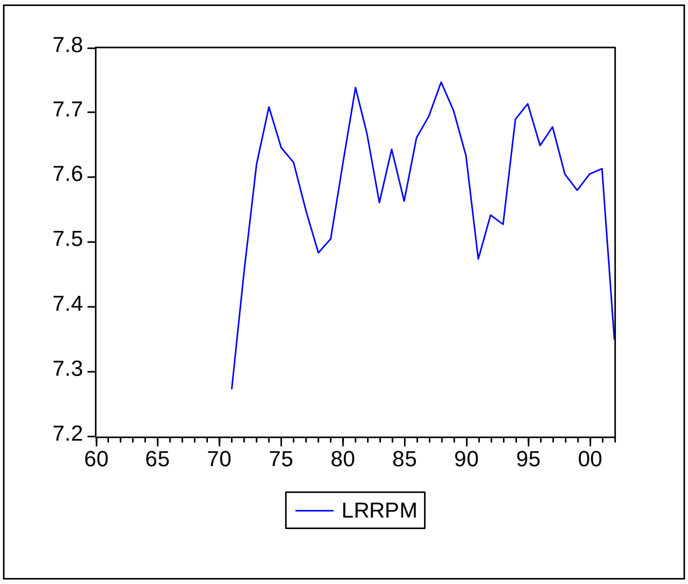


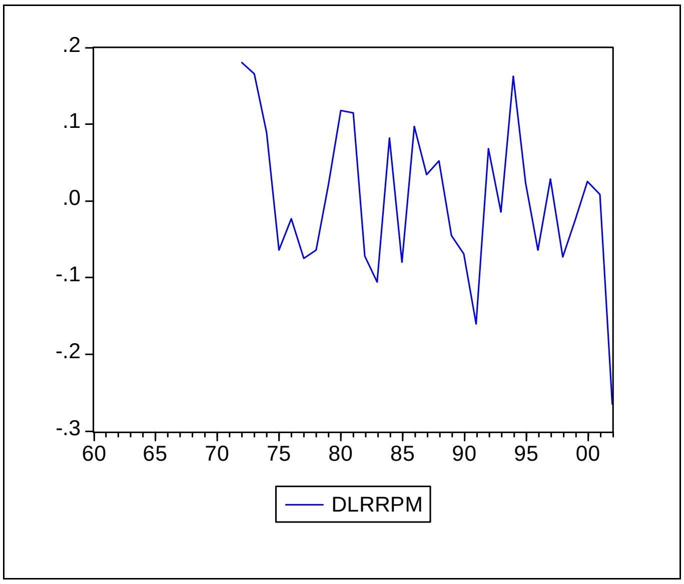
Real disposable income per capita of households (RDIPC)





Real retail price of mutton (RRPM)





Real retail price of beef (RRPB)

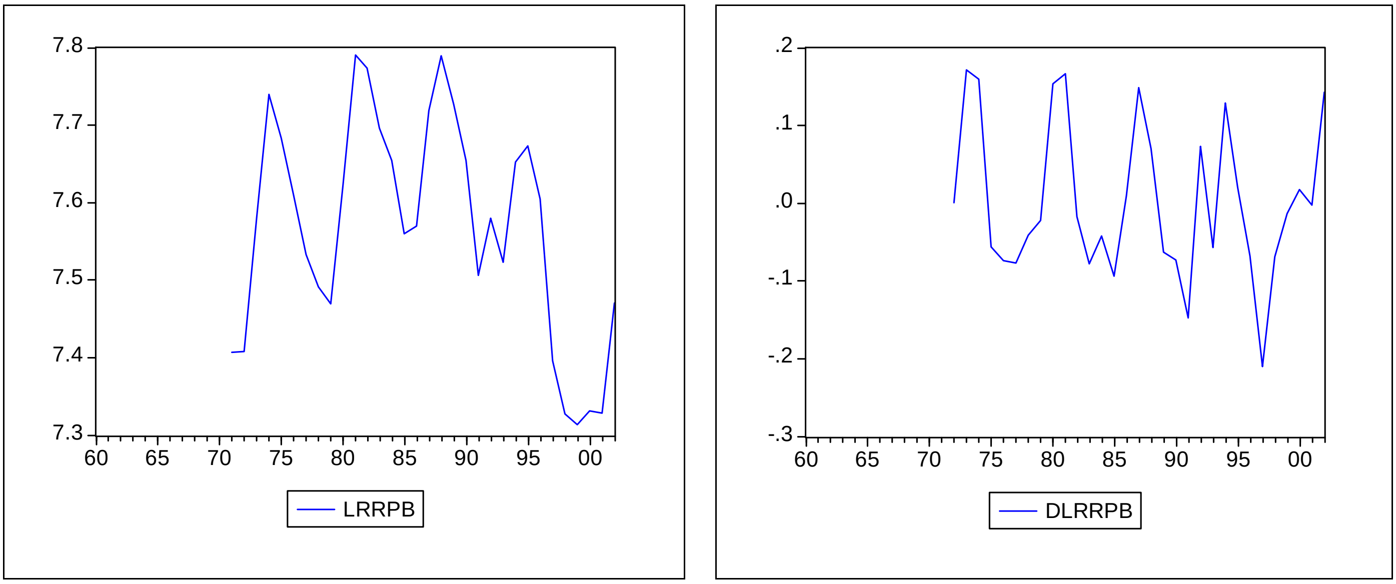


Table 5-14. Unit root test results on additional auction price system data

Variable	Model	ADF Lags	τ_τ, τ_μ, τ	Φ_3, Φ_1	PP lags	PP
LTSM	t, c	1	-2.684	3.787	3	-1.673
	c	1	-2.789*	5.515	3	-2.096
	none	2	-0.142		3	-0.001
DLTSM	t, c	1	-5.064***	9.379***	3	-6.295***
	c	1	-4.985***	13.521***	3	-4.527***
	none	1	-5.051***		3	-4.631***
LTSB	t, c	1	-2.502	2.823	3	-1.967
	c	1	-2.448	3.823	3	-2.155
	none	0	0.545		3	0.779
DLTSB	t, c	3	-4.668***	6.827***	3	-5.074***
	c	3	-4.530***	8.150***	3	-5.071***
	none	0	-5.194***		3	-5.115***
LRDIPC	t, c	0	-3.615**	6.699***	3	-3.527**
	c	0	-3.613***	13.063***	3	-3.553***
	none	0	0.357		3	0.534
DLRDIPC	t, c	0	-6.139***	18.910***	3	-6.880***
	c	0	-6.246***	39.008***	3	-7.007***
	none	0	-6.348***		3	-7.152***
LRRPM	t, c	1	-3.360**	4.839***	3	-3.312**
	c	1	-3.643***	7.174***	3	-3.817***
	none	0	0.095		3	0.092
DLRRPM	t, c	2	-4.281***	6.408***	3	-4.094**
	c	0	-4.069***	16.553***	3	-3.815***
	none	0	-4.210		3	-3.997***
LRRPB	t, c	1	-4.203***	7.604***	3	-2.653
	c	2	-3.525***	8.364***	3	-2.332
	none	3	-0.628		3	0.072
DLRRPB	t, c	2	-5.049***	7.366***	3	-3.409*
	c	2	-5.277***	9.972***	3	-3.481**
	none	2	-5.309***		3	-3.550***

Note: *** to mark the level of significance, * for 10%, ** for 5% and *** for 1%

From both the graphs and formal unit root tests it is evident that all of the additional data used in the auction price system were non-stationary.

Table 5-15. Stability tests on auction price system data

Variables	RESET statistic
LTSM	32.360***
LTSB	34.266***
LRDIPC	34.468***
RRPM	35.833***
RRPB	35.631***

Note: *** to mark the level of significance, * for 10%, ** for 5% and *** for 1%

The stability tests presented in Table 5-15 suggest that structural breaks are present in all the additional data used in the auction price system.

5.5.3 Results of the empirical estimation of auction prices paid to SA producers

5.5.3.1 Single equation estimation results for auction price equations

In all cases, the dependant variables (ap_i) were fitted in both nominal and real terms. As in the case of the estimation of slaughtering equations, the PPI for agricultural products was used to adjust the producer price. The retail and import price were adjusted with the CPI. All of these are notated by R e.g. rap_i. All prices are expressed in index form and notated by I e.g. api_i.

First order serial correlation was also detected in all cases. For the same reasons as in the case of the estimation of slaughtering equations, it was decided not to correct for first-order serial correlation.

5.5.3.1.1 Auction price of mutton

Table 5-16 presents the best fit of the auction price of mutton single equation estimation and Table 5-17 the battery of diagnostic tests that was performed.

Table 5-16. Auction price of mutton single equation estimation results

Dependent Variable: LRAPMI				
Method: Least Squares Date: 05/28/04 Time: 13:36 Sample(adjusted): 1971 2002 Included observations: 32 after adjusting endpoints				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LRRPMI	0.327451	0.109912	2.979207	0.0058
LTSM	-0.350631	0.065500	-5.353115	0.0000
C	1.731807	0.331471	5.224607	0.0000

R-squared	0.590797	Mean dependent var	-0.086129
Adjusted R-squared	0.562576	S.D. dependent var	0.099007
S.E. of regression	0.065481	Akaike info criterion	-2.525040
Sum squared resid	0.124347	Schwarz criterion	-2.387628
Log likelihood	43.40065	F-statistic	20.93471
Durbin-Watson stat	2.103721	Prob(F-statistic)	0.000002

Table 5-17. Diagnostic test results of the auction price of mutton equation

Test for	Test	Test Statistic	p-value	Conclusion
Normality	JB	2.978	0.226	Errors normally distributed
Serial correlation	DW	2.104		Negative serial correlation
	LM(2)	0.650	0.723	No serial correlation
	LM(3)	1.253	0.740	No serial correlation
Heteroscedasticity	ARCH(1)	0.008	0.929	No heteroscedasticity
	ARCH(2)	0.371	0.831	No heteroscedasticity
	ARCH(3)	0.405	0.939	No heteroscedasticity
	White(10)	3.019	0.555	No heteroscedasticity

All the variables are independently significant. Fifty nine percent of the variation in the RAPM is explained by the variation in the explanatory variables and the F-statistic of 21 indicates that all the variables are jointly significant in explaining the RAPM. The price received by domestic mutton producers is influenced by the retail price and total supply. All the signs of estimated coefficients were consistent with expectations. The coefficients, which are also the elasticities, were inelastic with respect to the auction price of mutton in all cases, except for the constant.

5.5.3.1.2 Auction price of beef

Table 5-18 presents the best fit of the auction price of beef single equation estimation and Table 5-19 the battery of diagnostic tests that was performed.

Table 5-18. Auction price of beef single equation estimation results

Dependent Variable: LRAPBI				
Method: Least Squares Date: 05/28/04 Time: 14:11 Sample(adjusted): 1971 2002 Included observations: 31 after adjusting endpoints				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LRDIPC(-4)	-0.709284	0.314949	-2.252058	0.0330
LRRPBI	0.670317	0.075873	8.834735	0.0000
LTSB	-0.426487	0.144665	-2.948093	0.0067
LTT	0.069329	0.020275	3.419501	0.0021
C	9.066632	2.426829	3.735999	0.0009

R-squared	0.797903	Mean dependent var	-0.045143
Adjusted R-squared	0.766811	S.D. dependent var	0.108845
S.E. of regression	0.052561	Akaike info criterion	-2.907008
Sum squared resid	0.071828	Schwarz criterion	-2.675720
Log likelihood	50.05862	F-statistic	25.66277
Durbin-Watson stat	2.077037	Prob(F-statistic)	0.000000

Table 5-19. Diagnostic test results of the auction price of beef equation

Test for	Test	Test Statistic	p-value	Conclusion
Normality	JB	2.258	0.323	Errors normally distributed
Serial correlation	DW	2.077		Negative serial correlation
	LM(2)	1.764	0.414	No serial correlation
	LM(3)	3.449	0.327	No serial correlation
Heteroscedasticity	ARCH(1)	0.043	0.837	No heteroscedasticity
	ARCH(2)	0.160	0.923	No heteroscedasticity
	ARCH(3)	2.333	0.506	No heteroscedasticity
	White(10)	7.626	0.471	No heteroscedasticity

All the variables are independently significant. Eighty percent of the variation in the RAPB is explained by the variation in the explanatory variables and the F-statistic of 26 indicates that all the variables are jointly significant in explaining the RAPB. The price received by beef producers is influenced by disposable income, the retail price, total supply and the effect of time. All the signs of estimated coefficients were consistent with expectations and, with the exception of the constant, were inelastic with respect to the auction price of beef.

5.5.3.1.3 Auction price of chicken meat

Table 5-20 presents the best fit of the auction price of chicken meat single equation estimation and Table 5-21 the battery of diagnostic tests that was performed.

Table 5-20. Auction price of chicken meat single equation estimation results

Dependent Variable: LRAPCI				
Method: Least Squares Date: 05/29/04 Time: 09:58 Sample(adjusted): 1971 2001 Included observations: 31 after adjusting endpoints				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LRDIPC	-1.010289	0.392198	-2.575967	0.0160
LRRPCI	0.488908	0.128543	3.803458	0.0008
LTSC	0.285211	0.110909	2.571579	0.0162
LTT	-0.120753	0.064790	-1.863769	0.0737
C	5.446795	3.700460	1.471924	0.1530

R-squared	0.497638	Mean dependent var	-0.061989
Adjusted R-squared	0.420351	S.D. dependent var	0.081797
S.E. of regression	0.062276	Akaike info criterion	-2.567795
Sum squared resid	0.100835	Schwarz criterion	-2.336507
Log likelihood	44.80082	F-statistic	6.438871
Durbin-Watson stat	1.082574	Prob(F-statistic)	0.000969

Table 5-21. Diagnostic test results of the auction price of chicken meat equation

Test for	Test	Test Statistic	p-value	Conclusion
Normality	JB	0.800	0.670	Errors normally distributed
Serial correlation	DW	1.083		Positive serial correlation
	LM(2)	5.236	0.073	No serial correlation
	LM(3)	5.285	0.152	No serial correlation
Heteroscedasticity	ARCH(1)	9.426	0.002	No heteroscedasticity
	ARCH(2)	10.000	0.007	No heteroscedasticity
	ARCH(3)	9.947	0.019	No heteroscedasticity
	White(10)	19.295	0.007	No heteroscedasticity

All the variables are independently significant, except for the constant. Fifty percent of the variation in the RAPC is explained by the variation in the explanatory variables and the F-statistic of 6 indicates that all the variables are jointly significant in explaining the RAPC. The price received by chicken meat producers is influenced by disposable income, the retail price, total supply and the effect of time. All the signs were consistent with expectations, except for TSC. The auction price of chicken meat is inelastic with respect to RRPC, SLC and the TT; and elastic with respect to RDIPC and the constant. Due to the fact that the sign of a key variable is in contrast with what is expected according to economic theory, it was decided not to use the chicken meat auction price equation in further analysis.

5.5.3.2 Auction price system estimation results

The best single equation estimation results as presented in Tables 5-16 and 5-18 were combined in an auction price system, and presented in Table 5-22.

Table 5-22. Auction price system estimation results

System: S_AUCTION_PRICES				
Estimation Method: Seemingly Unrelated Regression Date: 05/29/04 Time: 10:18 Sample: 1971 2002 Included observations: 32 Total system (balanced) observations 64 Linear estimation after one-step weighting matrix				
	Coefficient	Std. Error	t-Statistic	Prob.
C(11)	1.693425	0.273259	6.197132	0.0000
C(12)	0.324385	0.093112	3.483799	0.0010
C(13)	-0.343141	0.054015	-6.352734	0.0000
Equation: LRAPMI = C(11) + C(12)*LRRPMI + C(13)*LTSM				
C(21)	8.549379	1.746843	4.894190	0.0000
C(22)	-0.719179	0.223959	-3.211206	0.0022
C(23)	0.645126	0.058665	10.99681	0.0000
C(24)	-0.330074	0.108604	-3.039247	0.0036
C(25)	0.061734	0.014454	4.271019	0.0001
Equation: LRAPBI = C(21) + C(22)*LRDIPC(-4) + C(23)*LRRPBI + C(24)*LTSB + C(25)*LTT				

All the identified variables from the single equation estimation remained statistically significant in the system estimation. The subsequent elasticities were in the same order as in the respective single equation estimations although they have now been accepted to be better estimations.

In order to run some policy simulation experiments to evaluate the impact of alternative importation strategies or policies on the imports of live sheep for slaughtering purposes, the auction price and slaughtering systems needs to be combined. As the auction price system has been reduced to include only mutton and beef, the slaughtering system that was estimated in section 5.3.2 will also have to be reduced.

5.5.4 Reduced slaughtering system estimation results

Table 5-23 presents results of a reduced meat slaughtering system, including only mutton and beef.

Table 5-23. Reduced meat slaughtering system estimation results

System: S_SLAUGHTERINGS				
Estimation Method: Seemingly Unrelated Regression				
Date: 05/29/04 Time: 10:26				
Sample: 1974 2002				
Included observations: 29				
Total system (unbalanced) observations 57				
Linear estimation after one-step weighting matrix				
	Coefficient	Std. Error	t-Statistic	Prob.
C(11)	-10.54762	6.865592	-1.536302	0.1316
C(12)	2.554220	0.407144	6.273504	0.0000
C(13)	-0.430232	0.153649	-2.800103	0.0076
C(14)	1.218337	0.392845	3.101318	0.0034
C(15)	-0.644258	0.110054	-5.853998	0.0000
C(16)	-0.017787	0.002493	-7.135215	0.0000
C(17)	0.205353	0.162430	1.264255	0.2128
Equation: LSLM = C(11) + C(12)*LMA5RRPMI + C(13)*LRAPBI + C(14)*LHNS(-2) + C(15)*LMA5RS + C(16)*MA5NIM + C(17)*LRAPMI(-5)				
C(21)	2.446448	0.494461	4.947711	0.0000
C(22)	0.564561	0.316652	1.782905	0.0815
C(23)	-1.050535	0.104297	-10.07258	0.0000
C(24)	-0.298956	0.118334	-2.526381	0.0152
C(25)	0.391538	0.114556	3.417884	0.0014
C(26)	0.790519	0.100818	7.841024	0.0000
Equation: LSLB = C(21) + C(22)*LMA7RAPBI + C(23)*LRAPMI + C(24)*LRAPCI(-3) + C(25)*LRPYMI(-7) + C(26)*LMA7VIFCP				

5.5.5 Validation of the meat sub-sector model

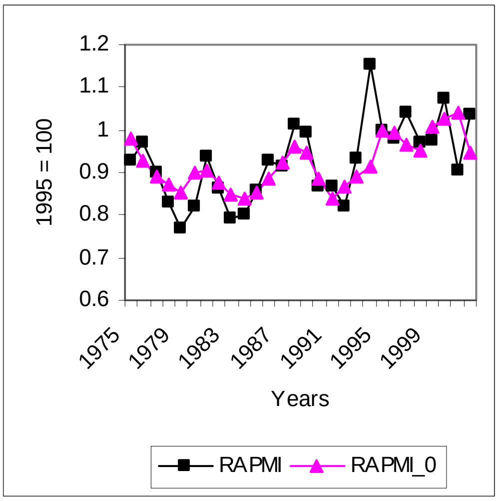
Before using the model for policy analysis and simulations it is important to be validated. This is done through in sample forecasting, based on ex post within the sample data (1975 – 2002). The dynamic-deterministic simulation of the Gauss-Seidel solution was used and resulted in relatively good fits, considering the data problems discussed in sections 5.2 and 5.5.2 and the statistical problems identified in section 5.3.1.

With the dynamic-deterministic simulation, lagged endogenous variables were calculated using the solutions calculated in previous periods. All equations in the model wee solved so that they hold without error during the simulation period, all coefficients were held fixed at their point estimates, and all exogenous variables were held constant. This resulted in a single path for the endogenous variable, which can be evaluated by solving the model once.

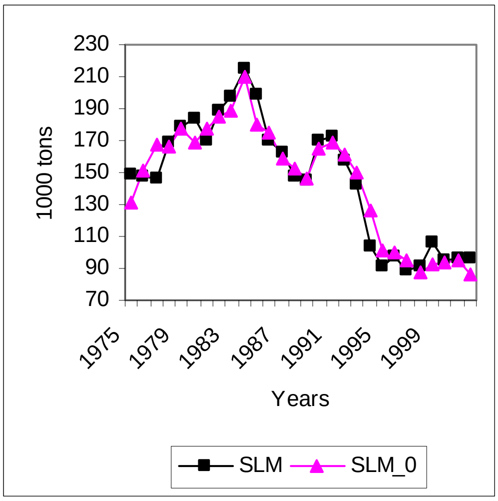
Accordingly, the ability of the model to generate observed historic data was tested and presented in Figures 5-4. In all cases the black lines represent the actual data upon which the model was based and the pink lines represent the base-line simulation forecasts. In other words, the models ability to reproduce the actual data is evaluated by comparing actual and forecasted values, which clearly indicates the goodness of the empirical model to simulate the past and have its ability to predict future changes in response to potential policy changes.

Figures 5-4. Baseline results of the meat sub-sector model

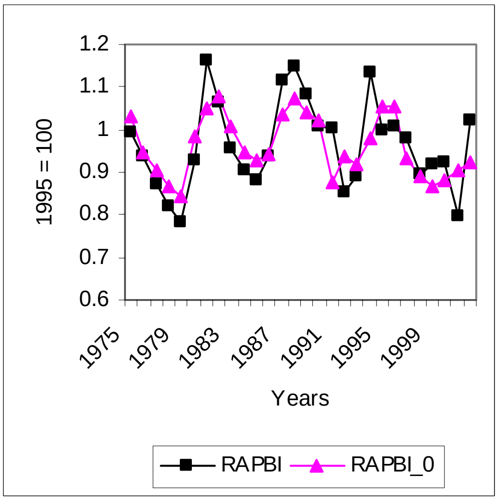
Real auction price of mutton



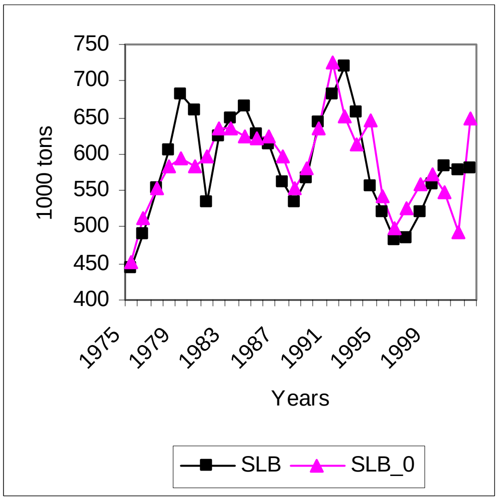
Slaughterings for mutton



Real auction price of beef



Slaughterings for beef



5.5.6 Scenario results

The estimated model was employed to evaluate the impact of alternative regimes or policy strategies on the domestic meat sub-sector. Since it is the objective of this study to evaluate the impact of live sheep importation policies the following scenarios were evaluated:

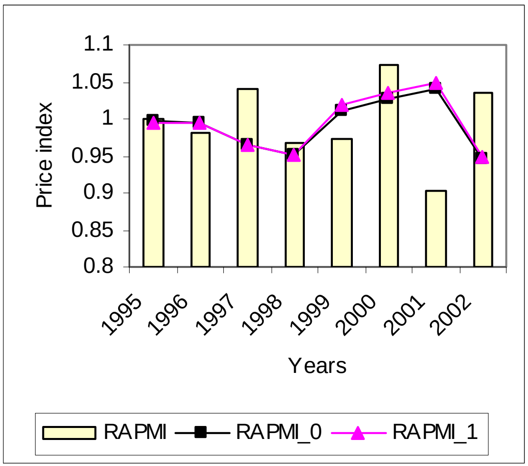
Scenario 1. Vessels utilised by the Australian live sheep export trade can accommodate up to 100 000 sheep at a time. As soon as these sheep set foot on South African soil, they will be slaughtered. Therefore, the weight of the total carcass of 23 kg (Venter, 2004) was used to determine imports. Assuming that the import permit application in 1995 was granted, imports would have increased by 2.3 thousand tons. This represents an additional 5.9 % of the 39 thousand tons imported during that year. A more realistic assumption would be, that should the permit have been granted in 1995 for the import of at least a 100 000 sheep, similar applications would have been received on a yearly basis. Accordingly the scenario where imports would have increased by 5.9 % in every year, as from 1995 up to 2002, was tested.

Scenario 2. As it is impossible to anticipate to what extent imports will increase and, it was decided to also test an extreme scenario in order to determine the meat sector's sensitivity towards changes in policy. Accordingly, the scenario where imports would have increased by 100 % in every year was tested. For 1995 that is, for example, an increase from 39 to 78 thousand tons.

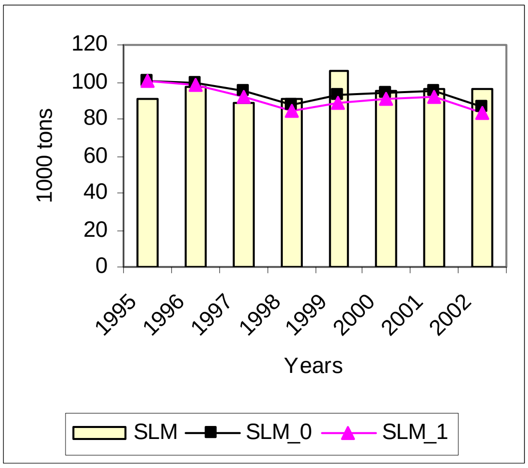
The results presented below on scenario 1 and 2 were obtained through the dynamic-deterministic simulation of the Gauss Seidel solution. In all cases the bars represent the actual data upon which the model was based. The black lines represent the base line, in other words, the models ability to reproduce the actual data. The pink lines represent the policy scenario tested, in other words, how the endogenous variables reacted to the shock.

Figures 5-5. Scenario 1 results

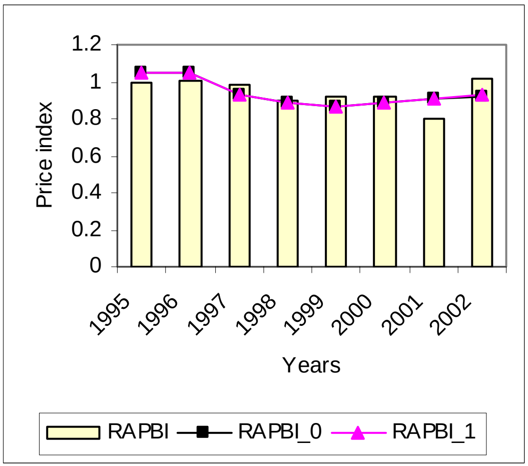
Real auction price of mutton index



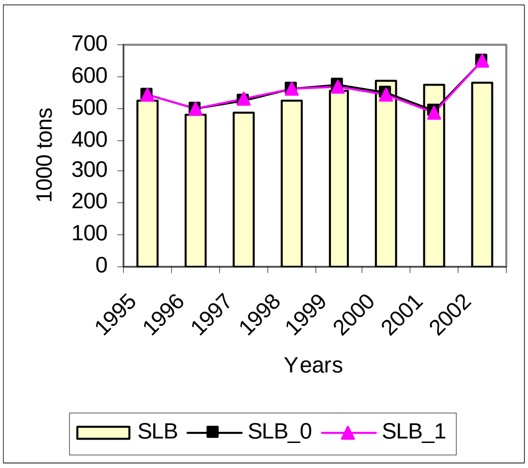
Slaughterings for mutton



Real auction price of beef index



Slaughterings for beef



Generally, it is clear from the figures in 5-5 that a yearly addition of 2.3 thousand tons of mutton imported for the period 1995 to 2002 would not have led to big adjustments in any of the meat industries in terms of the quantities slaughtered and the price paid to producers. As expected, the biggest response would have been in slaughterings for mutton (Table 5.24).

Table 5-24. Percentage change between scenario 1 and the base line

Years	RAPMI	SLM	RAPBI	SLB
1995	-0.37	-0.77	-0.10	0.38
1996	-0.12	-1.49	-0.03	0.12
1997	-0.17	-2.59	-0.04	0.16
1998	-0.03	-3.78	0.00	0.02
1999	0.75	-4.40	0.23	-0.78
2000	0.78	-4.14	0.24	-0.79
2001	0.78	-3.78	0.23	-0.78
2002	0.31	-3.25	0.08	-0.27

Imports of mutton were included in the model through both the slaughtering for mutton and real auction price of mutton equations, in the case of the slaughtering for mutton equation, through the five year moving average of the net imports (im – em) variable and in the case of the real auction price of mutton equation, through the total supply of mutton (slm + im) variable. Both of these exogenous variables were negatively related to the respective dependant variables. Although it is expected that an increase in the imports of mutton will result in a decrease in domestic slaughterings as well as a decrease in auction prices, the net effect will depend on the change relative to respective exports and slaughterings.

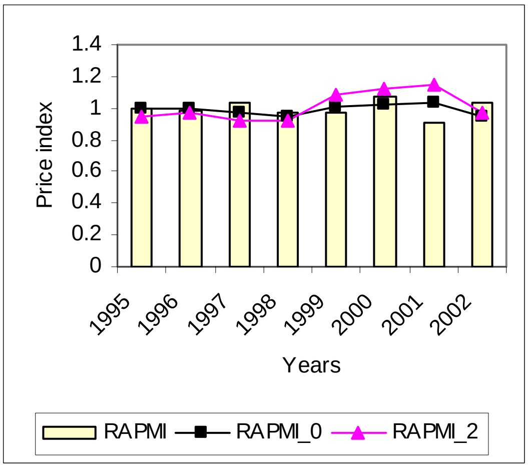
The interactions between the different meat industries are extremely complex as illustrated by a discussion of the first scenario's results presented in Table 5-24. Within the first year of increased mutton imports, slaughtering for mutton would decrease with only 0.77 %. Slaughterings would then continue decreasing to reach a maximum reduction of 4.40 % in 1999. However by 2002, reduction in slaughtering for mutton would recover to, more or less, the same levels slaughtered at in 1998. It is interesting to note that slaughterings of mutton was the only variable that decreased over the whole period, while the rest of the endogenous variables changed direction between 1998 and 1999. These direction changes are believed to be caused by a five-year cycle for mutton production build into the model.

Within the first year of increased mutton imports, the real auction price of mutton showed relatively stronger reaction, decreasing by 0.37 %. By 1999, prices would start to increase to reach a turning point in 2000 / 2001 at 0.78 %.

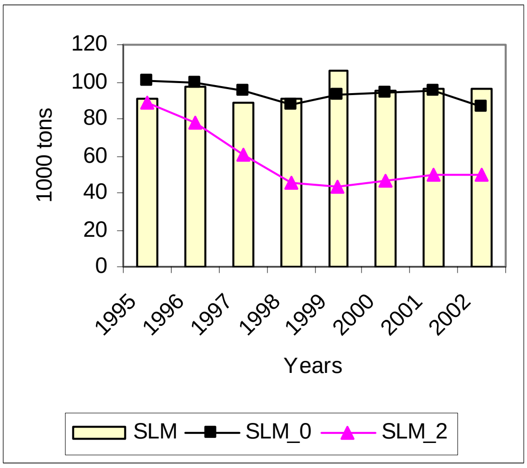
Within the first few years after increased mutton imports, slaughterings for mutton would have been substituted by beef despite the fact that the auction price of beef would also have decreased. The decrease in auction prices, however, would have been less for beef than for mutton e.g. making slaughtering for mutton relatively less attractive compared to beef, up to the point when slaughtering for beef start to decline from 1999 onwards, leading to auction beef prices to appreciate.

Figures 5-6. Scenario 2 results

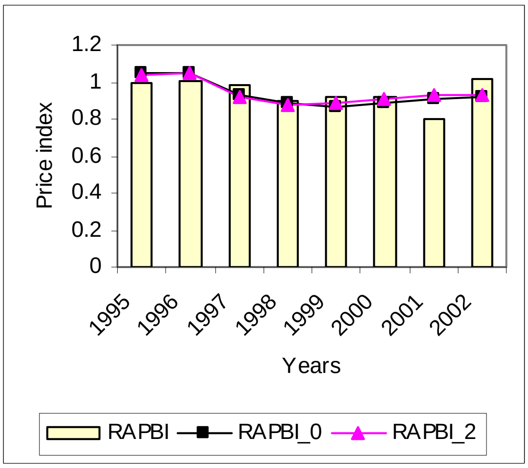
Real auction price of mutton index



Slaughterings for mutton



Real auction price of beef index



Slaughterings for beef

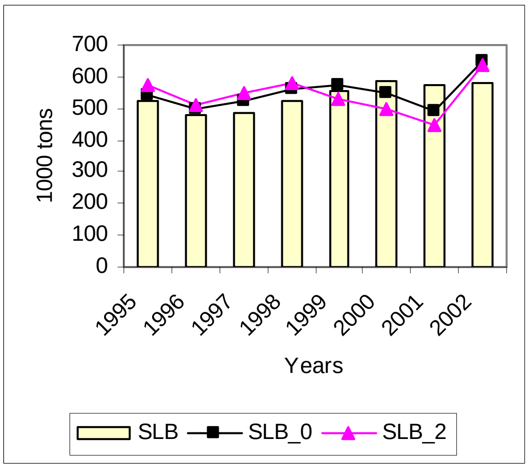


Table 5-25: Percentage change between scenario 2 and the base line

Years	RAPMI	SLM	RAPBI	SLB
1995	-5.80	-12.33	-1.65	6.32
1996	-2.63	-22.37	-0.68	2.63
1997	-4.24	-35.79	-1.19	4.34
1998	-3.60	-47.81	-1.01	3.54
1999	7.81	-53.11	2.42	-7.78
2000	9.06	-50.87	2.79	-8.70
2001	10.04	-47.86	2.98	-9.35
2002	2.13	-42.83	0.55	-1.76

It is clear from Figures 5-6 and Table 5-25 that even if mutton imports doubled over the period 1995 to 2002, it would still not have lead to big adjustments in either of the meat industries, with the exception of slaughterings for mutton, where levels decreased to a maximum of 53 %. Slaughterings for beef gained at the beginning (its turning point at 6 %) then declined eventually (its turning point at 9 %). Slaughterings for mutton declined throughout the period under review. In general, it can be concluded that although the meat sector is not very sensitive in its reaction to increased imports, the long-term effect will be negative on domestically produced meat. The next chapter will discuss recommendations, given the model's limitations and scenario results.

6.1 Summary

While a zero tariff applies to the importation of live animals for breeding, importation of live animals for slaughtering purposes is banned in SA. The DA is considering lifting the ban on importation of live sheep for slaughtering in response to increasing interest from meat suppliers. This study intended to evaluate the economic implications of allowing importation of live sheep for slaughtering purposes on the domestic meat market.

The study adopted a multi-market approach to conduct the intended analysis building on a recent meat demand system analysis by Adam (1998). Adam's (1998) meat demand system was to be complemented and extended to model the meat supply and factor market segments of the meat sector under market clearing conditions. This study's main contribution was the estimation of slaughtering functions for SA meat.

As the mutton industry is the focus of this study, the factor market segment of the meat sector was to include only the mutton land market. The demand equation for mutton producing areas was based on parameter estimates of a production function, representing the value of land in the sheep-grazing regions during 1986, estimated by Van Schalkwyk (1995). As sheep production is geographically situated in areas where land does not have any competitive production alternatives, the supply of land in sheep producing areas was assumed to be fixed at total areas available for field grazing.

In order to evaluate the policy question at hand, imports of meat was used as the policy instrument in the empirical model. It is argued that the effect of importing live sheep with the intention to slaughter on arrival will have the same economic implications as importing mutton of the equivalent amount.

Data were obtained for the period 1971 to 2002 to estimate a slaughtering system for meat on the following variables: slaughterings, own and substitute meat prices, production costs, prices of complementary products, prices of other production alternatives, exposure to world markets, quality of grazing and herd numbers.

In addition, historical data were needed on the variables included in Adam's (1998) Rotterdam demand system, as well as on Van Schalkwyk's (1995) regional production functions. Unfortunately, Van Schalkwyk (1995) did not publish, neither was he able to supply the data used in his estimations. Accordingly, the model was reduced to a sector model including only the product side of the meat market.

The study applied both single equation and systems econometric estimation procedures to generate estimates of the meat sector parameters. In the case of the pork slaughtering equation a negative relationship existed between slaughterings and the slaughtering price. This result was inconsistent with expectations. As the correct relationship with total supply is imperative in further analysis, it was decided to reduce the sector model to a sub-sector model, including only mutton, beef and chicken meat.

Accordingly it was found that a mutton producers' decision to slaughter is influenced by, the real own price the retailer realised over the past five years (2.554); the real price the beef producer realised in that same year (-0.344); the number of stock kept two years ago (1.285); the amount of rain that fell in the region, on average, during the last five years (-0.606); the degree of exposure to international trade, on average, during the last five years (-0.017); and the real own price the producer realised five years ago (0.169).

The beef producer's decision to slaughter is influenced by, on average, the combined real own price in the past seven years (0.699), the current real price for mutton producers received for their products (-1.038), the real price for chicken meat producers received for their products three years ago (-0.276), the real price paid for yellow maize seven years ago (0.364) and, on average, the combined seven year effect of the quality of grazing (0.753).

The chicken meat producer's decision to slaughter is influenced by the real own price (0.408), as well as the price of mutton and beef (0.500 and -0.369). The time trend (0.545) captures the effect of time on production decisions.

Despite its reported system wide R-square of 82 percent Adam's (1998) meat demand system did not give good in sample forecasts. Instead it was decided to account for demand factors indirectly through an auction price system. Necessary data could be obtained for the period 1971 to 2002 on the following variables: auction prices, total supply, income, retail prices and import prices.

In the case of the auction price of chicken meat equation the positive relationship with total supply of chicken meat was inconsistent with expectations. Accordingly, it was decided not to use the auction price of chicken meat estimation in further analysis, as the correct relationship with total supply is imperative in further analysis. As a result the sub-sector model is further reduced to include only the mutton and beef industries.

Accordingly, the price received by domestic mutton producers is influenced by the retail price (0.324) and total supply (-0.343). The price received by beef producers is influenced by disposable income received four years ago (-0.719), the retail price (0.645), total supply (-0.330) and the effect of time (0.062).

In order to run policy simulation experiments to evaluate the impact of alternative importation strategies or policies on the imports of live sheep for slaughtering purposes, the auction price and slaughtering systems needed to be combined. As the auction price system has been reduced to include only mutton and beef, the slaughtering system also needed to be reduced.

The sub-sector model was validated through in sample forecasting, based on ex post within the sample data applying the dynamic-deterministic simulation of the Gauss-Seidel solution. Considering the data and statistical constraints, the results were satisfactory and could accordingly be used to evaluate the implications of allowing importing live sheep for slaughtering on the domestic meat market.

6.2 Conclusions and policy implication of the study

The following two scenarios have been evaluated in policy simulations of the estimated meat sector model: (1) increasing imports by 5.9 % and (2) increasing imports by 100 %.

Policy scenario results as generated by the meat sub-sector model proved that the short-term impact of increased imports corresponds to the hypothesised implications, namely that lifting the embargo on live sheep imports will result in an increased supply of mutton on the domestic market at decreased consumer prices. Producer prices are expected to follow consumer prices and will accordingly also decrease. Decreased producer prices will result in decreased domestic slaughterings and, finally, increased imports will also decrease the price realised for substitute products. As the meat sub-sector, however, has time to adjust to increased levels of imports, some of the results seems to be surprising. Never the less, even the long-term effects remain negative, in general.

The fact that the meat sector is not very sensitive in its reaction to increased imports is not surprising seeing that most of its variables proved to be inelastic. This result is supported by the fact that it would be difficult to use the sheep-grazing areas of the country to support the production of other alternative agricultural commodities. Although the insensitivity of the meat market might make increased imports look like an attractive option, the reason therefore quite obviously clears this misconception, but raises concern for socio-economic problems in rural areas.

6.3 Limitations of the study and implications for future research

In SA most time series data are readily available as of the 1970's. This provides a history of 30 data points, which is sufficient given that series are stable, although relatively small in terms of most statistical techniques. Despite this relatively small sample, almost all time series data related to the meat sector also seems to have structural breaks. Most of these structural breaks are expected to be the result of liberalisation not only in terms of changes in farming practices and market structures, but also in terms of changes in data collection. In many cases institutions responsible for data collection were abolished without proper networks being in place between government and the private sector to keep up the important function of data collection. Almost 10 years down the line of liberalisation data seems to have become a valuable and expensive tradable commodity, not only supplied by government anymore. It is therefore of utmost importance that government and the private sector work together in order to secure reliable time series data that can be utilised statistically for policy analysis to the benefit of all SA citizens.

To improve SA's database is, however, a long-term solution to the statistical problems experienced in this study. For short-term result improvements of the policy question at hand it is recommended that the following be investigated:

- alternative or improved econometric estimation techniques in order to include the pork and chicken meat industries

- substitution of the auction price system with a demand / consumption system as initially planned either by estimation or by searching for new model results from the literature

- extension of the product side of the model to at least incorporate the production factor, land, as initially planned either by estimation or by searching for new model results from the literature

- revisiting of the assumption that all variables are stationary and the validity of applying the classical OLS estimation techniques

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APPENDIX A

The derivation and properties imposed by theory restrictions on Marshallian- and Hicksian demand

FOCs and derivatives of utility and demand

A great deal of consumer demand analysis is built on the assumption of a simple linear budget constraint:

$$p_i . q_i = x$$

with total expenditure *x*, prices p_i and quantities q_i. The consumer decides how much of each good to purchase by maximising his utility, given prices and total outlay. These relationships, giving quantities as a function of prices and total expenditures, are referred to as Marshallian demand functions (Deaton and Muelbauer, 1980; Sadoulet and De Janvry, 1989; Mansfield, 1991; Varian, 1996):

$$q_i = g(x, p_i)$$

In order to find Marshallian demand functions from the utility function the following problem needs to be solved:

Max $\quad u = v(q_i) \qquad$ subject to $\qquad p_i . q_i = x$

Using Lagrange's method, the problem can be rewritten as:

$$L = v(q_i) - \lambda(p_i . q_i - x)$$

Differentiating the Lagrange function with respect to q_i and λ constitute FOCs:

$$\frac{\partial L}{\partial q_i} = v(q_i) - \lambda p_i \qquad \text{and} \qquad \frac{\partial L}{\partial \lambda} = p_i q_i - x$$

Solving for q_i and λ generates the Marshallian demand functions. Substituting the Marshallian demand functions back into the original utility function, determines maximum utility:

$$u = v[g(x, p_i)]$$

The logarithmic derivatives of the Marshallian demands are the total expenditure elasticities and price elasticities. For the former, e_i, (with $i = 1, \ldots, n$)

$$e_i = \frac{\partial \log g(x, p_i)}{\partial \log x}$$

while for the latter, e_{ij}, (with $i, j = 1, \ldots, n$)

$$e_{ij} = \frac{\partial \log g(x, p_i)}{\partial \log p_j}.$$

The diagonal elements e_{ii} are the own-price elasticities, while off-diagonal e_{ij} elements are cross-price elasticities. These Marshallian elasticities are also known as uncompensated or gross elasticities.

<u>FOCs and derivatives of cost minimisation and the cost function</u>

In the above-mentioned section the consumers' problem was formulated as maximising utility for a given outlay or cost, giving a solution of some utility level. This problem can however be reformulated so as to find the amount of goods that would minimise the cost of producing some level of utility. This approach is referred to as the dual of consumer choice (Deaton and Muellbauer, 1980). The dual of the cost problem is built on the assumption of a utility constraint:

$$v(q_i) = u$$

with total utility u, and quantities q_i. The consumer decides how much of each good to purchase by minimising his cost, given utility. These relationships, giving quantities as a function of utility and prices, are referred to as Hicksian or compensated demand functions (Deaton and Muelbauer, 1980; Sadoulet and De Janvry, 1989; Mansfield, 1991; Varian, 1996):

$$q_i = h(u, p_i)$$

In order to find Hicksian demand functions from the cost function the following problem needs to be solved:

$$\text{Min} \quad x = p_i . q_i \quad \text{subject to} \quad v(q_i) = u$$

Using Lagrange's method, the problem can be rewritten as:

$$L = p_i q_i - \lambda [v(q_i) - u]$$

Differentiating the Lagrange function with respect to q_i and λ constitute FOCs:

$$\frac{\partial L}{\partial q_i} = p_i - \lambda . v(q_i) \quad \text{and} \quad \frac{\partial L}{\partial \lambda} = v(q_i) - u$$

Solving for q_i and λ from the FOC's, constitutes the Hicksian demand functions. Substituting the Hichsian demand functions back into the original cost function, determines minimum cost:

$$x = \sum p_i h(u, p_i)$$

The dual of the utility and cost functions can be used to formulate different procedures that ultimately determine the underlying Hicksian and Marshallian demand functions. First, it is possible to begin with a cost function specified in terms of utility and prices. Taking the derivative thereof, according to Shephards' Lemma, yields the Hicksian demand. Second, by substituting the maximising level of utility back into the Hicksian demand function, it is possible to derive Marshallian demands. Third, taking the derivative of the indirect utility function and applying Shephard's lemma, will yield Marshallian demands.

Properties of the utility based cost function:

Five important properties underlie the cost function (Deaton and Meullbauer, 1980):

Property 1. The cost function is homogeneous of degree one in prices, or formally, for a scalar $\theta > 0$

$$c(u, \theta p) = \theta c(u, p)$$

Property 2. The cost function is increasing in *u*, nondecreasing in *p*, and increasing in at least one price.

Property 3. The cost function is concave in prices.

Property 4. The cost function is continuous in *p*, and the first and second derivatives with respect to *p* exist everywhere except possibly at a set of specific price vectors.

Property 5. Where they exist, the partial derivatives of the cost function with respect to prices are the Hicksian demand functions, that is

$$\frac{\partial c(u, p)}{\partial p_i} \equiv h_i(u, p) = q_i$$

This property, known as Shephard's Lemma, is of central importance to the approach adopted here, because it allows a movement back from any known cost function to the cost-minimising demands that underlie it.

Properties of Marshallian and Hicksian demand functions:

Five important properties underlie the Marshallian and Hicksian demand functions (Deaton and Meullbauer, 1980):

Property 1: Adding up. The total value of both Hicksian and Marshallian demands is total expenditure, that is

$$\sum p_i h(u, p_i) = \sum p_i g(x, p_i) = x$$

Property 2: Homogeneity. The Hicksian demands are homogeneous of degree zero in prices, the Marshallian demands in total expenditure and prices together, that is, for scalar $\theta > 0$

$$h(u, \theta p_i) = h(u, p_i) = g(\theta x, \theta p_i) = g(x, p_i)$$

Property 3: Symmetry. The cross-price derivatives of the Hicksian demands are symmetric, that is, for all $i \neq j$

$$\frac{\partial h(u, p_i)}{\partial p_j} = \frac{\partial h(u, p_j)}{\partial p_i}$$

Property 4: Negativity. The *n*-by-*n* matrix, formed by the elements $\partial h_i / \partial p_j$ are negative semi-definete, that is, for any *n* vector ξ, the quadratic form

$$\sum_i \sum_j \xi_i \xi_j \frac{\partial h_i}{\partial p_j} \leq 0$$